Journal of the Fisheries Research Board of Canada

Volume 28, No. 12, December 1971

OHIO
APR 24 1972
BIOLOGICAL SCIENCES
APR 24 1972
LIBRARY
QH1
C192
c.2

Journal of the Fisheries Research Board of Canada

Volume 28, No. 12, December 1971

This number was issued on February 28, 1972.

The *Journal of the Fisheries Research Board of Canada* has been published continuously since 1901, previously as *Contributions to Canadian Biology* 1901–1925, *Contributions to Canadian Biology and Fisheries*, 1926–1934, and *Journal of the Biological Board of Canada*, 1934–1937. The *Journal* is published in annual volumes of twelve numbers.

The *Journal* is devoted to original research papers and notes concerning aquatic organisms or environments relevant to Canada. Review articles that are critical appraisals of broad areas of research are also welcomed. Submissions in English or French are accepted without limitations as to origin, but must not have been published or copyrighted. Details on submissions are given in guides to authors and typists at the back of each issue.

A charge of $30.00 per page is made for articles published. The change in format of this volume increases the printed matter per page by about 40 percent, and is reflected in the altered page charge. When submitting a manuscript, an author should state that his institution will accept this charge.

Subscription rates to the *Journal* are: Canada, United States, Mexico, $12.00 per year; other countries, $13.50. Single issues are $1.25 and $1.50 respectively. Orders must be sent directly to Information Canada, Ottawa, Canada, K1A 0S9.

Le *Journal of the Fisheries Research Board of Canada* a été publié sans interruption depuis 1901, sous les noms suivants: *Contributions to Canadian Biology* de 1901 à 1925, *Contributions to Canadian Biology and Fisheries* de 1926 à 1934, *Journal of the Biological Board of Canada* de 1934 à 1937 et finalement le nom qu'il porte présentement. Le *Journal* paraît annuellement en un volume comprenant douze numéros.

Le *Journal* est consacré aux études sur des recherches originales et aux notes concernant les organismes et les environnements aquatiques pertinents au Canada. Des critiques concernant des ouvrages généraux sont aussi appréciés. Des soumissions en anglais ou en francais sont acceptées sans limitations d'origine, sauf si elles ont déjà été publiées ou déposées. Des détails sont fournis dans les guides à la fin de chaque numéro.

Les frais sont de $30.00 par page pour la publication des articles. Le nouveau format de ce volume permet d'augmenter de 40 pour cent le nombre de caractères imprimés par page, ce qui justifie les nouveaux frais de publication de page. Quand un auteur soumet un manuscript, il doit spécifier que son institution accepte les frais.

Les frais de souscription au *Journal* sont: au Canada, aux Etats-Unis et au Mexique, $12.00 par année; autres pays, $13.50. Une seule copie se vend $1.25 et $1.50 respectivement. Les commandes doivent être envoyées directement à Information Canada, Ottawa, Canada, K1A 0S9.

Editor/Rédacteur and/et, Director of Scientific Information / Directeur de l'information scientifique: J. C. STEVENSON, PH.D.

Associate Editor / Rédacteur associé: L. W. BILLINGSLEY, PH.D.

Assistant Editors / Rédacteurs adjoints: R. H. WIGMORE, M.SC.; J. WATSON, PH.D.

Production: R. L. MACINTYRE/MONA SMITH, B.H.SC.

Documentation: J. CAMP

Office des recherches sur les pêcheries du Canada
Bureau du directeur de la publication
116, rue Lisgar, Ottawa, Canada
K1A 0H3

Fisheries Research Board of Canada
Office of the Editor, 116 Lisgar Street
Ottawa, Canada
K1A 0H3

Volume 28, No. 12, December 1971

Journal of the Fisheries Research Board of Canada

Effects of Handling and Salinity on Oxygen Requirements of the Striped Bass, *Morone saxatilis*[1]

MARK E. CHITTENDEN, JR.[2]

Department of Environmental Sciences
Rutgers, The State University, New Brunswick, New Jersey, USA

CHITTENDEN, M. E., JR. 1971. Effects of handling and salinity on oxygen requirements of the striped bass, *Morone saxatilis*. J. Fish. Res. Bd. Canada 28: 1823–1830.

Oxygen requirements of striped bass, *Morone saxatilis*, were studied at 0 and 10‰ salinity using combinations of handling and constantly decreasing oxygen concentrations. Effects of handling and salinity on oxygen requirements were negligible or absent. Successive and merging patterns of behavior at low oxygen concentrations were: restlessness, spasmodic swimming, surfacing, inactivity, equilibrium loss, and death. Mean oxygen levels with 99% confidence limits at restlessness, inactivity, equilibrium loss, and death were 1.81 ± .10, 1.28 ± .10, 0.95 ± .06, and 0.72 ± .04 mg/liter. Virtually no fish exhibited these behavior patterns until oxygen declined to 3.12, 2.19, 1.44, and 1.04 mg/liter, respectively; nearly all fish did at 0.91, 0.66, 0.62, and 0.50 mg/liter, respectively. Size of fish did not affect oxygen levels at death and equilibrium loss.

Ventilation rate was maximum at 2.0–3.0 mg/liter and declined at lower concentrations. Amplitude was maximum at the beginning of inactivity then declined. Because short-term respiratory failure occurred at equilibrium loss, this behavior probably represents oxygen levels that would cause an abrupt fish-kill. Long-term respiratory failure at inactivity indicated that death would follow a period of resistance.

There is no sharp distinction between suitable and unsuitable oxygen concentrations, because duration of exposure determines the intensity of the result even at lethal levels. Onset of restlessness (about 3 mg/liter at 16–19 C) probably represents the minimum permissible oxygen level for normal existence. Even this may be insufficient to maintain optimum populations of striped bass.

CHITTENDEN, M. E., JR. 1971. Effects of handling and salinity on oxygen requirements of the striped bass, *Morone saxatilis*. J. Fish. Res. Bd. Canada 28: 1823–1830.

---

[1]Paper in the Journal Series, New Jersey Agricultural Experiment Station, Rutgers, The State University, New Brunswick, New Jersey.

[2]Present address: Virginia Institute of Marine Science, Gloucester Point, Va. 23062.

Printed in Canada (J2218)

L'auteur étudie les exigences en oxygène du bar d'Amérique, *Morone saxatilis*, à des salinités de 0 et 10‰, combinant diverses méthodes de manipulation avec des teneurs sans cesse décroissantes d'O_2. La manipulation et la salinité affectent peu ou pas du tout les exigences en O_2 du poisson. Une faible teneur en O_2 déclenche une série de réactions s'enchaînant l'une à la suite de l'autre: agitation, nage spasmodique, montée en surface, inertie, perte d'équilibre et mort. Le niveau moyen d'O_2 une limite de la confiance de 99% auquel se produisent agitation, inertie, perte d'équilibre et mort est de $1.81 \pm .10$, $1.28 \pm .10$, $0.95 \pm .06$ et $0.72 \pm .04$ mg/litre respectivement. Pratiquement aucun poisson n'exhibe ces modalités de comportement avant que l'O_2 n'ait baissé à un niveau de 3.12, 2.19, 1.44 et 1.04 mg/litre respectivement, alors que presque tous les montrent à des teneurs respectives de 0.91, 0.66, 0.62 et 0.50 mg/litre. La taille du poisson n'affecte pas le niveau d'O_2 auquel se produisent la perte d'équilibre et la mort.

La vitesse de ventilation atteint un maximum à des teneurs en O_2 de 2.0–3.0 mg/litre et ralentit à des teneurs plus faibles. L'amplitude de ventilation est maximale au début de la phase d'inertie et diminue par la suite. Un arrêt respiratoire de courte durée au stade de perte d'équilibre nous porte à croire que ce comportement est caractéristique d'une teneur en O_2 suffisamment faible pour causer une mortalité catastrophique. Un arrêt respiratoire de longue durée au stade d'inertie indique que la mort surviendrait après une période de résistance.

La ligne de démarcation entre une teneur en O_2 adéquate et inadéquate est imprécise parce que la durée d'exposition est le facteur qui détermine l'intensité de la réaction, même au niveau léthal. Le début de l'état d'agitation (à environ 3 mg litre à 16–19 C) représente probablement le niveau minimal d'O_2 pour une existence normale. Il est même peut-être insuffisant au maintien de populations optimales de bars d'Amérique.

Received June 28, 1971

THE striped bass, *Morone saxatilis*, is an anadromous fish, which ranges along much of the United States coast. Spawning occurs from April to July at water temperatures of about 14–22 C, and fresh and estuarine waters are used for nurseries (Raney 1952; Talbot 1966).

Historical patterns of commerce and settlement have resulted in extensive industrial and municipal development and pollution along estuarine and tidal fresh waters adjacent to important spawning or nursery areas of the striped bass. Philadelphia on the Delaware River, Washington on the Potomac River, Richmond on the James River, and New York and Albany on the Hudson River are examples. A prominent characteristic of pollution in these rivers is oxygen depletion, yet there appears to be no published work on the oxygen requirements of striped bass. Such information is essential to evaluate the effects of pollution on this species.

Tolerance of fishes to experimental conditions can be greatly influenced by the history of pretest handling of the specimens and by handling during the experiments. For example, Chittenden (MS 1969) found that oxygen levels at death for the American shad, *Alosa sapidissima*, varied from 0.9 to 5.7 mg/liter and depended upon the handling to which the fish were subjected. Evaluation of tolerance studies requires a preliminary analysis of the effects of handling.

The objectives of these studies were to evaluate the effects of handling on oxygen requirements of the striped bass and to determine oxygen requirements of this species.

Materials and Methods

The experiment was a $2 \times 2 \times 6$ factorial in a randomized block design. The factors were salinity, transferral interval, and acclimation period. Transferral interval is the period of time that elapsed between successive removals of fish from holding troughs. Levels of this factor were 2 and 5 days. Acclimation period is the time that elapsed between introduction of a fish to an aquarium and the beginning of deoxygenation. Levels of this factor were 15 min, and 3, 6, 24, 27, and 30 hr. Levels of the salinity factor were 0 and 10‰.

Steel and Torrie (1960) describe procedures for estimating the number of replicates required to detect a chosen difference between treatments with a chosen probability. The variance of the experiment must be estimated in advance. Preliminary work found a range of 0.5 mg/liter for oxygen levels at death. Assuming a normal distribution, the range is approximately equal to 6σ, giving .0069 as the estimate of σ^2. Although I selected three replicates, only two could be run. I estimated that two replicates could detect a difference of less than 0.3 mg/liter between treatments at the 5% significance level with 90% probability. Smaller differences could be detected, but with less likelihood. The week of testing served as a block, because only one replicate could be run in a week.

Young-of-the-year striped bass were collected from the Hudson River at Stony Point, New York, on November 4, 1967, transported to the laboratory, and placed in a 2.4-m diam 0.6-m deep, 2840-liter blue vinyl swim-

ming pool. The fish were held in diluted sea water with salinities of 5–11‰, and the water was changed monthly. The pool was aerated and filtered constantly, had a rotary current, and was cleaned daily. The fish were fed minced clams 4–6 days each week and a mixture of pellet food, beef liver, sheep spleen, and pork lung on the other days. Apparently, because of agonistic interactions, one or more striped bass would die every few days. A few fish were always much darker in color than the others, and they could not compete successfully for food. Gradually the dark fish seemed to separate from the others and eventually died.

Fish were removed from the pool on March 7, 1968 and were randomly assigned to two holding troughs where they were allowed to acclimate to the media used in the experiment. One trough contained tap water dechlorinated in an activated charcoal column and the other contained diluted sea water (10‰ salinity). Maintenance of fish in the troughs was similar to that in the pool.

The vessels used during tests were standard 38-liter aquaria, which were numbered and externally painted a sandy-beige color lengthwise to prevent visual contact between fish in adjacent aquaria. The fish were readily observed through the unpainted sides. Media were randomly assigned to the vessels, which were continuously aerated except during oxygen removal. On March 12, 14, 19, and 21, fish were removed from the holding troughs, and one fish was randomly assigned to each aquarium.

Deoxygenation of a freshwater and a saltwater aquarium started at 0900 or 0915, 1200, and 1500 hr each day, and acclimation periods were randomly assigned to aquaria containing each medium. Oxygen was removed at a desired rate by bubbling nitrogen gas into the water at a predetermined pressure. Many workers have used nitrogen gas for deoxygenation (Whitworth and Irwin 1961; Moss and Scott 1961; Herrmann et al. 1962). The oxygen level changed from saturation to 1.0 mg/liter in a mean time of 62 min (range 53–79) and 52 min (range 41–59) in fresh and salt water, respectively.

A timer turned the laboratory lights on at 0630 and off at 2030 hr. Water temperatures in the holding troughs and aquaria were 16–18.5 C. The mean total length and weight of the fish was 90 mm (range 81–108) and 6.5 g (range 3.1–11.7), respectively.

Water samples were taken at 15-min intervals and when death occurred. Dissolved oxygen was determined by the Winkler method. Behavior was related to the oxygen level by plotting dissolved oxygen against time. Behavior patterns observed in these studies were: (1) death — no visible opercular movement occurred after 15 sec observation; (2) equilibrium loss — fish first noticed on its side or back; (3) inactivity — ventral surface of fish first rested on bottom of aquarium; and (4) restlessness — fish first started to move constantly around sides of aquarium.

In addition, periodic observations of ventilation rate and amplitude were made for each fish. Ventilation rate was expressed quantitatively by using a stop watch to determine time elapsed during 15 respiratory movements. Although ventilation amplitude was not measured quantitatively, comments on comparative amplitude were recorded as each fish was tested.

Results

Effects of Handling Upon Oxygen Requirements

Oxygen levels at death ranged from 0.5 to 2.6 mg/liter, but 45 of the 48 observations were from 0.5 to 0.9 mg/liter. At equilibrium loss they ranged from 0.7 to 2.9 mg/liter, although 45 of the 48 observations were from 0.7 to 1.2 mg/liter. Oxygen levels at inactivity were 0.9–6.4 mg/liter, but 44 of the 48 observations were in the range 0.9–1.8 mg/liter. The value of 6.4 was recorded for a fish that rested on the bottom but displayed none of the other characteristics of this behavioral stage. This value was excluded from further analyses. The next highest oxygen level at inactivity was 3.2 mg/liter. Oxygen levels at restlessness were from 1.3 to 3.7 mg/liter, and 45 of the 48 observations were from 1.5 to 2.6 mg/liter. It was difficult to identify the beginning of this stage exactly, so the values recorded may be slightly in error.

Residuals represent variation not explained by the analysis of variance model describing each observation (Draper and Smith 1966). Residuals were calculated and then examined for the presence of outliers in the oxygen levels observed at death and equilibrium loss by graphical methods and by significance testing with r ratios (Dixon and Massey 1969). Outliers found in the dissolved oxygen values recorded at death (2.6, 1.4, and 1.1 mg/liter) and equilibrium loss (2.9, 1.7, and 1.5 mg/liter) were excluded from further analyses. They involved three fish from the first group transferred to aquariums. The probable reason for the outliers is that the three fish were sick, because the persistent mortality of dark fish in the holding pool continued in the holding troughs. I placed a few dark fish in the aquariums on the first transferral date, and these may have been the fish for which outlier oxygen values were recorded. The fish dying at 2.6 mg/liter dissolved oxygen was very dark. I did not transfer dark fish thereafter and no further outliers occurred. Values recorded for the three sick fish were also excluded from analyses for the inactivity and restlessness stages.

Table 1 summarizes an analysis of variance for differences between treatments based upon oxygen levels at death. Dummy values were computed and were substituted for the missing data to simplify the calculations (Steel and Torrie 1960). The error mean square was slightly less than the estimate based upon preliminary data. Therefore, the desired precision and power of the significance tests were achieved. The three-factor interaction was signif-

icance at $\alpha = .05$ and the acclimation periods (AP) × transferral intervals (TI) interaction at $\alpha = .10$. The main effects were not significant nor were the other two-factor interactions, and the F values did not approach significance.

The significant interactions were examined using Duncan's new multiple range test. The significant AP × TI interaction was due to the 6- and 27-hr acclimation periods. Differences between transferral intervals were significant at 27 hr (Table 2) and approach significance at 6 hr. Differences between transferral intervals in the 6- and 27- hr acclimation periods and the significant three-factor interaction were due to the saltwater tests (Table 3). There was a significant difference between transferral intervals for tests performed in salt water but not in fresh water. In the 6-hr acclimation period, death occurred at the highest oxygen levels with a 5-day transferral interval. In the 27-hr acclimation period, death occurred at the highest oxygen levels with a 2-day transferral interval. The reversal in response to transferral interval indicates that the reason for the significant differences may not be physiological.

An analysis of variance was also performed for the equilibirum loss and inactivity stages. The findings for equilibrium loss were similar to those for death. Each main effect and interaction was significant for the inactivity stage. This is surprising because the error mean square in that analysis was much larger than for the equilibrium loss and death stages. Therefore, the analyses for the death and equilibrium loss stages were more sensitive to differences but did not detect any. The significant differences might not be due to an effect on the fish. Total oxygen values at inactivity on successive days in the 1st week were 8.2, 7.7, 7.4, and 7.2 mg/liter, and in the 2nd week 8.5, 7.8, 7.3, and 6.7 mg/liter. There is a trend from high values to successively lower values each week; no trend was apparent for oxygen values at death and equilibrium loss. I suspect the trend reflects progressively later recognition, due to observer fatigue, of the beginning of inactivity, and this may be the reason for the slight, but significant, differences involving acclimation periods and transferral intervals. This might not explain the significant difference (at $\alpha = .10$) between salinities, but the difference was negligible, the mean in salt water being .08 mg/liter higher than in fresh water.

TABLE 1. Summary of the analysis of variance for differences in oxygen levels at death.

Source of variation	df	Sum of squares	Mean square	F
Total	44	.35312		
Weeks	1	.00187	.00187	<1
Acclimation periods (AP)	5	.01937	.00387	<1
Transferral intervals (TI)	1	.00020	.00020	<1
Salinities (S)	1	.00187	.00187	<1
AP × TI	5	.07605	.01521	2.28478
AP × S	5	.00438	.00088	<1
TI × S	1	.00188	.00188	<1
AP × TI × S	5	.11437	.02287	3.43393
Error	20	.13313	.00666	

TABLE 2. Summary of the examination of the AP × TI interaction.* indicates significant difference between transferral intervals in a given acclimation period at $\alpha = 0.05$.

Treatment combination		Mean
AP_{15}	TI_5	.75
	TI_2	.72
AP_3	TI_2	.70
	TI_5	.70
AP_6	TI_5	.75
	TI_5	.65
AP_{24}	TI_5	.78
	TI_2	.73
AP_{27}	TI_2	.80
	TI_5	.65*
AP_{30}	TI_2	.73
	TI_5	.68

TABLE 3. Summary of the examination of the TI × S interaction for AP_6 and AP_{27}. * indicates significant difference between transferral intervals in a given acclimation period and salinity at $\alpha = 0.05$.

Treatment combination			Mean
AP_6	TI_2	S_{fw}	.70
	TI_5	S_{fw}	.70
AP_6	TI_5	S_{sw}	.80
	TI_2	S_{sw}	.60*
AP_{27}	TI_2	S_{fw}	.75
	TI_5	S_{fw}	.70
AP_{27}	TI_2	S_{sw}	.85
	TI_5	S_{sw}	.60*

General behavioral observations also provide information about the effects of handling on oxygen requirements of this species. Unlike the behavior reported for the American shad (Chittenden 1969), striped bass did not lose equilibrium or die when being handled, and they did not seem excited when introduced to the aquariums.

I conclude that, unlike the American shad, the striped bass is phlegmatic while being handled and the effects of handling on oxygen requirements of striped bass appear to be neglible or absent.

The outlier values observed indicate that the additional stress associated with illness makes striped bass more vulnerable to low oxygen levels.

Effects of Dissolved Oxygen Level on Behavior

General behavior was similar in both fresh and salt water and was closely related to dissolved oxygen level. Two patterns could be distinguished. "Normal" behavior occurred at higher oxygen values. Almost immediately after introduction to the aquarium, the fish assumed a position about an inch above the bottom. Most fish movements that occurred were usually slow, but occasionally the fish became excited and dashed against the side of the aquarium briefly.

An abrupt change occurred when the dissolved oxygen decreased to low values. This behavior pattern was characterized by a group of reactions that successively appeared as oxygen decreased, and that merged until death occurred. The symptoms of this low oxygen syndrome in order of appearance were: (1) constant swimming along the aquarium sides in an increasingly violent manner; (2) swimming in bursts of spasmodic activity, particularly at the surface; (3) resting with the stomach on the bottom whereby the fish almost lose equilibrium but recover; (5) equilibrium loss; and (6) death.

Ventilation amplitude and rate were closely related to dissolved oxygen concentration. The relation between ventilation rate and oxygen level based upon 322 timings exclusive of those from the sick fish is presented in Fig. 1. More than 150 timings were made at oxygen levels below 2.0 mg/liter exclusive of those at death. The ventilation rate at death was 4 gulps/min, and this value was assigned to 0.7 mg/liter, the mean oxygen level at death.

Rate and amplitude of ventilation increased with declining oxygen when oxygen was still relatively high. The greatest ventilation rate occurred at about 2.0–3.0 mg/liter, but decreased with further decline in oxygen level. The decrease in ventilation rate was precipitous when dissolved oxygen levels slightly above 1.0 mg/liter were reached. In contrast, amplitude continued to increase with declining oxygen until the beginning of the inactivity behavior stage (mean = 1.3 mg/liter). Thereafter amplitude also declined.

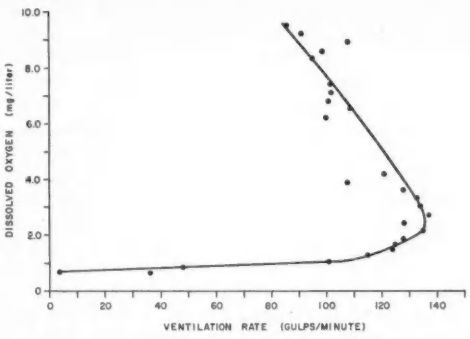

FIG. 1. Effects of dissolved oxygen concentration on ventilation rate. Each point represents mean ventilation rate for intervals of 0.3 mg/liter above 2.0 mg/liter and intervals of 0.2 mg/liter below 2.0 mg/liter dissolved oxygen. Curve fitted by eye.

Means, pooled variances, and 99% confidence limits of the mean for oxygen levels at death, equilibrium loss, inactivity, and restlessness were:

Behavior stage	s^2	$\bar{x}$	Lower confidence limit of $\bar{x}$	Upper confidence limit of $\bar{x}$
Death	.008	0.72	0.68	0.76
Equilibrium loss	.019	0.95	0.89	1.00
Inactivity	.064	1.28	1.17	1.38
Restlessness	.133	1.81	1.71	1.91

Outliers and dummy values were excluded from the calculation of these data. Assuming a normal distribution, it is highly probable that mean oxygen level at death lies within the confidence limits. Oxygen levels at which the individual fish died are distributed about the mean, and confidence interval techniques can be used to estimate the percentage of exposed fish that will die at a given oxygen level. Table 4 presents predictions based on the observed mean at death and similar predictions at equilibrium loss, inactivity, and restlessness. A variance suitable for prediction (Steel and Torrie 1960) was used in calculating the confidence limits for individuals. Values of t were obtained from Fisher and Yates (1957). Predictions based upon the upper and lower confidence limits of the mean can be obtained by addition or subtraction of 0.036, 0.055, 0.103, and 0.10 to or from the dissolved oxygen values for death, equilibrium loss, inactivity, and restlessness, respectively.

TABLE 4. Summary of predicted oxygen levels for several oxygen requirements of striped bass. Values in mg/liter. Calculations were based on observed means.

%	Death	Equilibrium loss	Inactivity	Restlessness
0.05	1.04	1.44	2.19	3.12
0.5	.97	1.32	1.97	2.81
1.0	.94	1.28	1.90	2.71
5.0	.87	1.18	1.71	2.43
10.0	.84	1.13	1.61	2.29
20.0	.80	1.07	1.50	2.13
30.0	.77	1.02	1.42	2.01
40.0	.74	.99	1.35	1.90
50.0	.72	.95	1.28	1.81
60.0	.70	.91	1.21	1.72
70.0	.67	.88	1.14	1.61
80.0	.64	.83	1.06	1.49
90.0	.60	.77	.95	1.33
95.0	.57	.72	.85	1.19
99.0	.50	.62	.66	.91

The observed mean oxygen level at death was 0.72 mg/liter, and only 0.08 mg/liter separates the upper and lower confidence limits of the mean. A complete mortality of exposed striped bass would occur by the time the dissolved oxygen level declined to 0.46 mg/liter if the lower confidence limit of the mean was used for prediction purposes. Virtually no mortality would be observed until the dissolved oxygen declined to 1.08 mg/liter if the upper confidence limit of the mean was used for prediction. The difference in oxygen level between virtually complete and no mortality is about 0.5 mg/liter.

The observed mean oxygen level at equilibrium loss was 0.95 mg/liter, confidence limits being 0.89 and 1.00 mg/liter. Virtually no exposed fish would lose equilibrium until the dissolved oxygen declined to 1.44 mg/liter if predictions were based upon the observed mean. Predictions for death and equilibrium loss overlap at the lower oxygen levels, and overlap similarly occurs with the other behavior stages. Obviously, predictions for the most adverse response take precedence.

For death and equilibrium loss, residuals were plotted against total length of the fish (Fig. 2). No relation is apparent between these oxygen requirements and size.

The observed mean oxygen level at inactivity was 1.28 mg/liter, with confidence limits of 1.17 and 1.38 mg/liter. Virtually no fish would exhibit this behavior until the dissolved oxygen declined to 2.19 mg/liter, if predictions were based upon the observed mean.

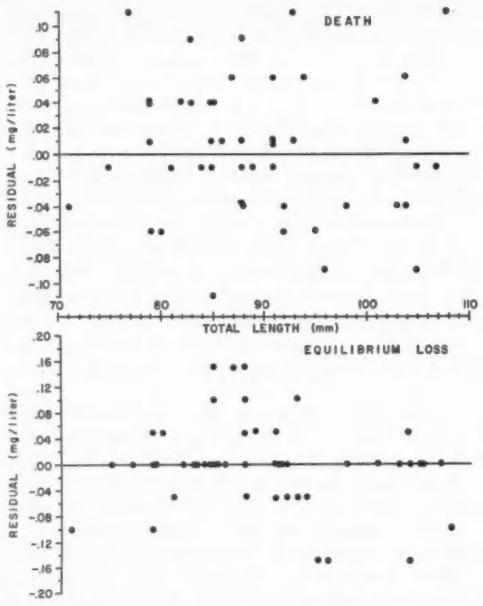

FIG. 2. Relations between fish length and residuals. Residuals represent variation not explained by the mathematical model for dissolved oxygen concentrations at death and equilibrium loss.

The observed mean oxygen level at the restlessness stage was 1.81 mg/liter, confidence limits being 1.71 and 1.91 mg/liter. Virtually no fish would exhibit this behavior pattern until the oxygen level declined to 3.12 mg/liter if predictions were based upon the observed mean.

Discussion

Dissolved oxygen levels at death may not be those causing death when the levels continuously decrease, because resistance may permit fish to temporarily exist at lethal oxygen concentrations. Shepard (1955) found that resistance time decreased as the oxygen level at death decreased. Resistance may greatly extend life at high lethal oxygen levels. For example, Mount (1961) reported a white bass, *Morone chrysops*, that existed 35 hr at a lethal dissolved oxygen of 2 mg/liter. Such feats of resistance are rarely necessary. When organic pollution affects dissolved oxygen levels, short-term fluctuations of about 6–12 hr between oxygen minima and maxima typically occur due to photosynthesis and tidal movement of polluted water. My data indicates the responses expected when the dissolved

oxygen rapidly decreases. Complete description of expected behavior requires examining the effect that rate of oxygen change has on oxygen requirements.

Burdick et al. (1954) considered the death point as the oxygen level at which complete equilibrium loss occurred, the fish resting motionless on its side. They reported that it was often impossible to revive the fish. My definition of equilibrium loss was not as intense a condition initially, but the striped bass exhibited respiratory failure shortly after I declared equilibrium loss. There was a precipitous decrease in ventilation rate and amplitude, and respiration became spasmodic. As a result, it appears that oxygen levels inducing equilibrium loss closely approximate the short-term lethal levels for striped bass and may result in abrupt fish-kills.

Although the rate of ventilation was declining, amplitude increased to a maximum at the beginning of the inactivity stage of behavior. Because both the rate and amplitude of ventilation decreased thereafter, probably the fish cannot supply sufficient oxygen to maintain life for extended periods of time. The characteristic lack of motion at this stage may represent an attempt by the organism to adapt to an unfavorable environment by decreasing energy expenditure, but this could only be temporary. Being no longer adapted to its environment and unable to move, the fish must eventually die. Oxygen levels inducing this behavior may cause a continuous but gradual high mortality of striped bass.

Krouse (MS 1968) reported complete mortality of striped bass exposed for 72 hr to nominal levels of 1.0 mg/liter dissolved oxygen and some mortality at concentrations of 3.0 mg/liter. The true oxygen levels fluctuated to much lower concentrations, particularly in the nominal 3.0 mg/liter level, which fell below 1.0 mg/liter in some tests. It is impossible to say what the true lethal levels were, but they seem close to my results.

The oxykinetic level (Fry 1960) marks the beginning of the restlessness stage of behavior and indicates an avoidance reaction. Whitmore et al. (1960) reported avoidance of oxygen levels well above lethal levels by certain salmonid and centrachid fish. Fry (1960) stated that, because of continued movement, oxygen levels inducing restlessness in fish may not permit maintenance of a population in a given locality. Because increased activity exerts a greater energy demand, the fish must compensate by obtaining additional energy through feeding, by drawing upon energy reserves, by inhibiting other energy demands, or by finding a more favorable environment.

The behavior patterns characterized as the low oxygen syndrome seem to represent a general phenomenon among fish. These patterns have been reported for a wide variety of fish (Mount 1961; Bouck and Ball 1965; Hoff et al. 1966; Whitworth and Irwin 1961; Shepard 1955). Other behavior patterns that I did not observe on striped bass may also be part of the low oxygen syndrome. Mount (1961) and Bouck and Ball (1965) observed that fish lost their normal coloration under low oxygen conditions. These authors, Hoff et al. (1966), and Shepard (1955) also reported that low oxygen levels may adversely affect the appetite. The effects of no feeding or limited feeding are probably time-dependent and may become more serious as the response is prolonged.

Increased ventilation rate or amplitude in response to low oxygen has been reported by many workers, including Mount (1961), Bouck and Ball (1965), Hoff et al. (1966), and Whitworth and Irwin (1961). Van Dam (cited by Fry 1957) found that efficiency of oxygen removal decreased as the ventilation volume increased. Although the fish would have to do more work to extract the same benefit, no problem exists if other energy demands are not greatly inhibited. Because the rate of ventilation decreased about when the low oxygen syndrome began, unless increased amplitude fully compensates, it would appear that striped bass can no longer provide sufficient oxygen to meet the demands of normal existence.

There is no sharp distinction between suitable and unsuitable dissolved oxygen concentrations, because even at lethal levels duration of exposure determines the intensity of the result. Oxygen levels at death, equilibrium loss, and the inactivity stages of behavior are far too low to be permissible minima at any time. As Tarzwell (1958) and Fry (1960) point out, dissolved oxygen just sufficient to keep fish alive is not enough. In nature, fish must be active, feed, grow, migrate, and reproduce. Within species specific limits, these activities become more intense with increasing water temperature and oxygen requirements increase. Oxygen requirements of striped bass appear unaffected by salinity in the range 0 to about 10‰. The oxykinetic level that marks the beginning of the low oxygen syndrome seems to be the minimum realistic oxygen level permissible at any time, so that dissolved oxygen concentrations of about 3.0 mg/liter may represent the minimum that enables striped bass to exist normally at water temperatures near 16–19 C. Even this amount may be insufficient to maintain optimum populations. Doudoroff and Shumway (1967) summarized work on sublethal effects of low dissolved oxygen, and reported that swimming

ability, development, and growth of fishes may be limited by oxygen supply, even near saturation levels. Repeated exposure to low oxygen levels as caused by diurnal fluctuations can have adverse effects almost as pronounced as continuous exposure to low concentrations. Further work is needed on the effects of sublethal dissolved oxygen concentrations on striped bass because, as Bouck and Ball (1965) stated, such conditions, although not causing death, may reduce the ability of desirable fishes to compete with rough fishes in the modified environment.

Acknowledgments

I am indebted to my wife, Susan, for helping to collect the fish and to Dr J. A. Musick of the Virginia Institute of Marine Science for reviewing the manuscript. K. Stubblefield of the Virginia Institute of Marine Science drew the figures. Financial support was provided by the Department of Environmental Sciences, Rutgers University, and by the Office of Water Resources Research, Department of the Interior, with matching funds by the Delaware River Basin Commission and the New Jersey Department of Conservation and Economic Development.

BOUCK, G. R., AND R. C. BALL. 1965. Influence of a diurnal oxygen pulse on fish serum proteins. Trans. Amer. Fish. Soc. 94: 363–370.

BURDICK, G. E., M. LIPSCHUETZ, H. J. DEAN, AND E. J. HARRIS. 1954. Lethal oxygen concentrations for trout and smallmouth bass. N.Y. Fish Game J. 1: 84–97.

CHITTENDEN, M. E., JR. MS 1969. Life history and ecology of the American shad, *Alosa sapidissima*, in the Delaware River. Ph.D. Thesis. Rutgers University, New Brunswick, New Jersey. 458 p.

DIXON, W. J., AND F. J. MASSEY, JR. 1969. Introduction to statistical analysis. 3rd ed. McGraw-Hill, New York, N.Y. 638 p.

DOUDOROFF, P., AND D. L. SHUMWAY. 1967. Dissolved oxygen criteria for the protection of fish. Amer. Fish. Soc. Spec. Publ. 4: 13–19.

DRAPER, N. R., AND H. SMITH. 1966. Applied regression analysis. John Wiley & Sons, New York, N.Y. 407 p.

FISHER, R. A., AND F. YATES. 1957. Statistical tables for biological, agricultural and medical research. 5th ed. Oliver & Boyd, London. 138 p.

FRY, F. E. J. 1957. The aquatic respiration of fish, p. 1–63. *In* M. E. Brown [ed.] The physiology of fishes. Academic Press, Inc., New York, N.Y.

1960. The oxygen requirements of fish, p. 106–109. *In* Biological problems in water pollution (Trans. of the 1959 Seminar). U.S. Public Health Serv., Robert A. Taft Sanit. Eng. Center, Tech. Rep. W60–3.

HERRMANN, R. B., C. E. WARREN, AND P. DOUDOROFF. 1962. Influence of oxygen concentration on the growth of juvenile coho salmon. Trans. Amer. Fish. Soc. 91: 155–167.

HOFF, J., M. E. CHITTENDEN, JR., AND J. R. WESTMAN. 1966. Oxygen requirements of some marine and anadromous fishes, with particular reference to problems of measurement. Proc. 21st Ind. Waste Conf. Eng. Bull. Purdue Univ. 50: 125–140.

KROUSE, J. S. MS 1968. Effects of dissolved oxygen, temperature, and salinity on survival of young striped bass, *Roccus saxatilis* (Walbaum). M.S. Thesis. Univ. of Maine, Orono, Me. 61 p.

MOSS, D. D., AND D. C. SCOTT. 1961. Dissolved oxygen requirements of three species of fish. Trans. Amer. Fish. Soc. 90: 377–393.

MOUNT, D. I. 1961. Development of a system for controlling dissolved oxygen content of water. Trans. Amer. Fish. Soc. 90: 323–327.

RANEY, E. C. 1952. The life history of the striped bass, *Roccus saxatilis* (Walbaum). Bull. Bingham Oceanogr. Collect. 14: 5–97.

SHEPARD, M. P. 1955. Resistance and tolerance of young speckled trout (*Salvelinus fontinalis*) to oxygen lack, with special reference to low oxygen acclimation. J. Fish. Res. Bd. Canada 12: 387–446.

STEEL, R. G. D., AND J. H. TORRIE. 1960. Principles and procedures of statistics. McGraw-Hill, New York, N.Y. 481 p.

TALBOT, G. B. 1966. Estuarine environmental requirements and limiting factors for striped bass. Amer. Fish. Soc. Spec. Publ. 3: 37–49.

TARZWELL, C. M. 1958. Dissolved oxygen requirements for fishes, p. 15–20. *In* Oxygen relationships in streams. U.S. Public Health Serv., Robert A. Taft Sanit. Eng. Center, Tech. Rep. W58–2.

WHITMORE, C. M., C. E. WARREN, AND P. DOUDOROFF. 1960. Avoidance reactions of salmonid and centrarchid fishes to low oxygen concentrations. Trans. Amer. Fish. Soc. 89: 17–26.

WHITWORTH, W. R., AND W. H. IRWIN. 1961. The minimum oxygen requirements of five species of fish under quiescent conditions. Proc. Annu. Conf. S. E. Ass. Game Fish Comm. 15: 3–11.

Geographic Distribution and Relative Abundance of Salpidae off the Oregon Coast

LYLE T. HUBBARD, JR.[1] AND WILLIAM G. PEARCY

Department of Oceanography
Oregon State University, Corvallis, Oreg. 97331, USA

HUBBARD, L. T., JR., AND W. G. PEARCY. 1971. Geographic distribution and relative abundance of Salpidae off the Oregon coast. J. Fish. Res. Bd. Canada 28: 1831–1836.

Six species of salps were identified from 437 midwater trawl and 202 plankton net collections off Oregon from 1961 to 1964: *Helicosalpa virgula*, *Iasis zonaria*, *Salpa fusiformis*, *Pegea confoederata*, *Thalia democratica*, and *Thetys vagina*. Relative abundance of the species varied in time and space and few distributional patterns were evident. *Salpa fusiformis* and *I. zonaria*, the most common species, were found during all seasons of the year, the highest numbers usually during the summer, the upwelling season. *Thalia democratica*, *H. virgula*, and *T. vagina* were found only during 1963, and *P. confoederata* was most common during 1963. This was an abnormally warm year and the presence of these species off Oregon may have been related to advection from the south or west and the lack of upwelling.

HUBBARD, L. T., JR., AND W. G. PEARCY. 1971. Geographic distribution and relative abundance of Salpidae off the Oregon coast. J. Fish. Res. Bd. Canada 28: 1831–1836.

Nous avons identifié six espèces de salpes provenant de 437 traits de chalut pélagique et 202 traits de filet à plancton effectués au large des côtes de l'Orégon de 1961 à 1964: *Helicosalpa virgula*, *Iasis zonaria*, *Salpa fusiformis*, *Pegea confoederata*, *Thalia democratica* et *Thetys vagina*. L'abondance relative des espèces varie dans le temps et dans l'espace et les schémas de répartition sont à peu près nuls. *Salpa fusiformis* et *I. zonaria*, les espèces les plus communes, se rencontrent en toutes saisons avec maximum en été, saison de la remontée d'eaux profondes. *Thalia democratica*, *H. virgula* et *T. vagina* n'ont été capturés qu'en 1963, année où *P. confoederata* fut le plus commun. Cette année-là fut exceptionnellement chaude et la présence de ces espèces au large des côtes de l'Orégon peut être attribuable à l'advection en provenance du sud ou de l'ouest et à l'absence de remontée d'eaux profondes.

Received May 20, 1971

MOST species of salps are cosmopolitan warmwater plankters, and their incursions into colder zones may indicate the intrusion of warm water into cold-water zones (Thompson 1948; Yount 1958; Fraser 1962). Species that occur in temperate waters often show sporadic and enormous fluctuations in numbers that are possibly related to hydrographic conditions (Braconnot 1963; Sewell 1953). Dense patches or swarms, which may result from direct transport of swarms or reproduction en route, may drastically affect phytoplankton and zooplankton populations. Fraser (1949, 1962), for example, noted that standing stocks of copepods were scarce when salps were abundant.

The ocean off Oregon is generally cool. The water mass is modified Pacific subarctic water. During summer, prevailing winds create upwelling of cold water near the coast that counteracts the seasonal warming processes (Smith et al. 1966; Pattullo et al. 1969). The ocean environment off Oregon may therefore represent a northern boundary and not a salubrious environment for many species of salps. The purpose of this study was to determine the occurrence of salps off Oregon seasonally and geographically, to relate their occurrence to environmental conditions, and to learn if some species may be indicators of warmwater advection.

Methods

Collections of pelagic animals including salps were made from July 1961 through June 1963 at stations located along transect lines at right angles to the Oregon coast off the mouth of the Columbia River, Coos Bay,

[1]Present address: Department of Anthropology, University of Oregon, Eugene, Oreg., USA.

Printed in Canada (J2173)

and Brookings (Fig. 1). The lines extended from 5 to 165 nautical miles offshore, with stations at intervals of 10–20 miles. The Coos Bay, Newport, and Columbia River stations were usually sampled monthly and Brookings stations usually every 2 months from June 1962 through April 1964. A line to 145 miles off the Siuslaw River was sampled in November 1963. Salps were also collected on a cruise to the southwest of Oregon to 34°23′N, 140°46′W.

Collections were made with a 6-ft Isaacs-Kidd midwater trawl and 1-m diam plankton nets. From July 1961 to July 1962 the front half of the midwater trawl net consisted of 38-mm mesh (square measure) and the after half was lined with 13-mm mesh netting. After July 1962 the trawl was lined throughout with 5-mm knotless nylon mesh netting. The 1-m nets were made of nylon with mesh apertures of .571 mm. A flow meter in the mouth of the meter nets and a depth-distance recorder in the mouth of the midwater trawl provided estimates of the amount of water filtered during each tow. Both midwater trawl and meter net tows were made to 200 m, depth permitting, between dusk and dawn.

Meter net sampling in conjunction with the midwater trawling was begun May 1963. At first, the meter net was attached above the midwater trawl and both were towed simultaneously. These oblique tows were abandoned in favor of separate vertical tows in December 1963.

Midwater trawl collections contained most of the salps used in this study. Meter net collections usually did not filter enough water to effectively sample the generally sparse salp populations.

Two collection methods provided information on depth distribution of the salps within the upper 1000 m. A total of 116 samples from multiple opening–closing meter nets, operated by piston cutters (Yentsch et al. 1962), and 103 midwater trawl samples, taken with a Multiple Plankton Sampler attached to the codend of the trawl (Pearcy and Hubbard 1964), were examined for salps.

In all, 434 midwater trawl and 200 1-m net samples were examined for salps. Samples were preserved in 5% formalin at sea and sorted ashore. When there were fewer than 100 salps per sample, the entire sample was sorted for salps. If the sample contained many salps, a Folsom Plankton splitter (McEwen et al. 1954) was utilized to produce a subsample of at least 100 salps. Oozooids and blastozooids were counted separately but are treated together in the paper.

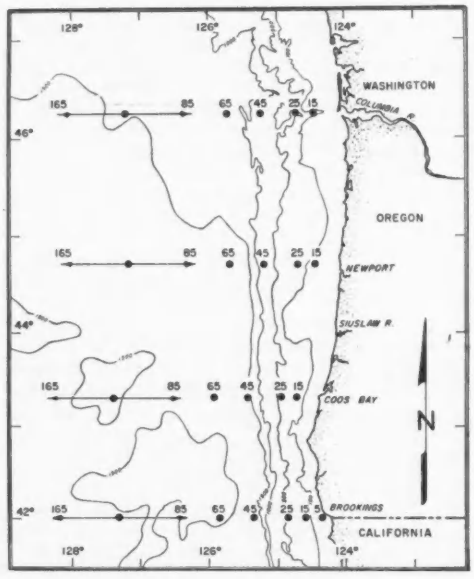

FIG. 1. Stations where collections of salps were made off the Oregon coast. Numbers indicate distances offshore in nautical miles. Stations at 20-mile intervals between 85 and 165 miles offshore were sampled less frequently than inshore stations and are not individually designated. (Bottom contours are in fathoms.)

Species Composition

Six species of salps were collected during the study: *Helicosalpa virgula*, *Iasis zonaria*, *Salpa fusiformis*, *Pegea confoederata*, *Thalia democratica*, and *Thetys vagina* (Table 1 and Fig. 2). The frequency of occurrence of each species was low. *Salpa fusiformis*, the most common salp, was found in less than 20% of all collections.

SALPA FUSIFORMIS CUVIER 1804

Salpa fusiformis, a common species of salp along the west coast of North America (Ritter 1905; Thompson 1948; Berner MS 1957), was the most abundant species collected. The frequency of occurrence and the average number per tow were lowest along the northern stations (Table 1).

The irregular occurrence of salps off Oregon is illustrated in Table 2, which shows the catches of *S. fusiformis* off Newport. This species was absent from most of the collections but, where it was present, numbers were often high. Patchiness in time and space is emphasized by the fact that when catches were made at one station during a month, it was often absent in adjoining stations for that month, or from the same station for preceding or succeeding months. Patches or swarms of this and other species of salps have been reported by Hardy (1936), Hardy and Gunther (1935), Fraser (1949), and Foxton (1966).

Salpa fusiformis occurred each month of the year at some time during the study, except October (Fig. 2). Thus its occurrence was not limited to any one season. Off Newport, there was a seasonal

TABLE 1. Frequencies of occurrence in percent and (in parentheses) average catches per midwater trawl of salps in 316 tows along four station lines 15–165 miles off Oregon, July 1961–June 1964. The average volume of water filtered by 309 tows was 13.5×10^3 m^3 (SD 3.7×10^3 m^3).

	Columbia River (56 tows)	Newport (123 tows)	Coos Bay (52 tows)	Brookings (85 tows)	Avg
Salpa fusiformis	9(12)	15(37)	33(38)	22(22)	19
Iasis zonaria	0(0)	4(0.4)	11(1.4)	33(1.9)	12
Pegea confoederata	2(<0.1)	2(0.3)	2(5.3)	2(0.2)	2.0
Thetys vagina	0(0)	2(0.6)	4(1.9)	1(0.6)	1.6
Thalia democratica	0(0)	4(1,190)	0(0)	1(0.6)	1.9
Helicosalpa virgula	0(0)	0(0)	2(<0.1)	0(0)	0.3

TABLE 2. Midwater trawl catches of *Salpa fusiformis* (number per 1000 m^3) at various stations off Newport, August 1961–May 1964 (0 = tows made but no salps caught; – no tows made).

Months	Nautical miles offshore 15	25	45	65	65+
			1961		
Aug.	0	0	0	–	–
Nov.	0	0	0	1.51	–
Dec.	0	0	0	0	0
			1962		
Jan.	0	0	0	0	0
Feb.	0	0	0	0	0
Apr.	–	0	–	–	0
May	0	0	0	0	135
June	–	–	1.01	518	77.3
July	0	0.42	0	2.09	–
Aug.	0.22	0.44	0.29	2.07	–
Sept.	0	0	0	1.82	0
Oct.	0	0	–	–	–
Nov.	0	0	0	0	–
Dec.	0	0	0	1.26	0
			1963		
Jan.	0	0	0	0	–
Feb.	0	0	0	0	0
May	–	0	0.24	0	0
June	–	0	0	4.50	–
July	–	–	0	0	0
Aug.	–	0	0	0	–
Sept.	0	–	–	–	0
Oct.	0	0	0	–	–
Nov.	0	0	4.47	0	–
Dec.	0	0.08	0	0	–
			1964		
Feb.	0	0	0.05	1.63	0
Mar.	0	0	0	0	–
Apr.	0	0	0	1.10	–
May	–	0	0	0	–

"bloom" from May through September 1962 when catches were high and it was the most numerous species (Table 2). However, it was not particularly common during the summers of 1961 and 1963 off Newport.

IASIS ZONARIA (PALLAS) 1774

Iasis zonaria, one of the most common salps in temperate waters (Thompson 1948), was second only to *S. fusiformis* in its occurrence and abundance. *Iasis zonaria* showed a very definite pattern in its latitudinal distribution. Both frequency of occurrence and catch per tow decreased from south to north (Table 1). It appeared most commonly off Brookings, where it occurred at all stations 15–165 miles offshore, and not at all off the Columbia River. This trend suggests a southerly center of abundance. Such a conclusion was supported by high catches of this species on a cruise south and west of Oregon between 43°10′N, 132°20′W and 36°34′N, 141°11′W, February–March 1965.

Iasis zonaria occurred most months of the year (Fig. 2), but highest catches were made in the spring and summer.

PEGEA CONFOEDERATA (FORSKÅL) 1775

Occurrence of *P. confoederata* off Oregon represents a significant extension of its known range. It is a truly warmwater species and is abundant in all warm and temperate oceans as far north as southern California (Thompson 1948).

The species occurred in only 2% of the collections during the study (Table 1). It was captured at least once on every station line. An interesting latitudinal change in the distance we found it offshore was apparent. The farther north we found this species, the closer to shore it occurred. It was collected 105–145 miles off Brookings, 65 miles off Coos Bay, 14–65 miles off Newport, and 15 miles offshore of the Columbia River.

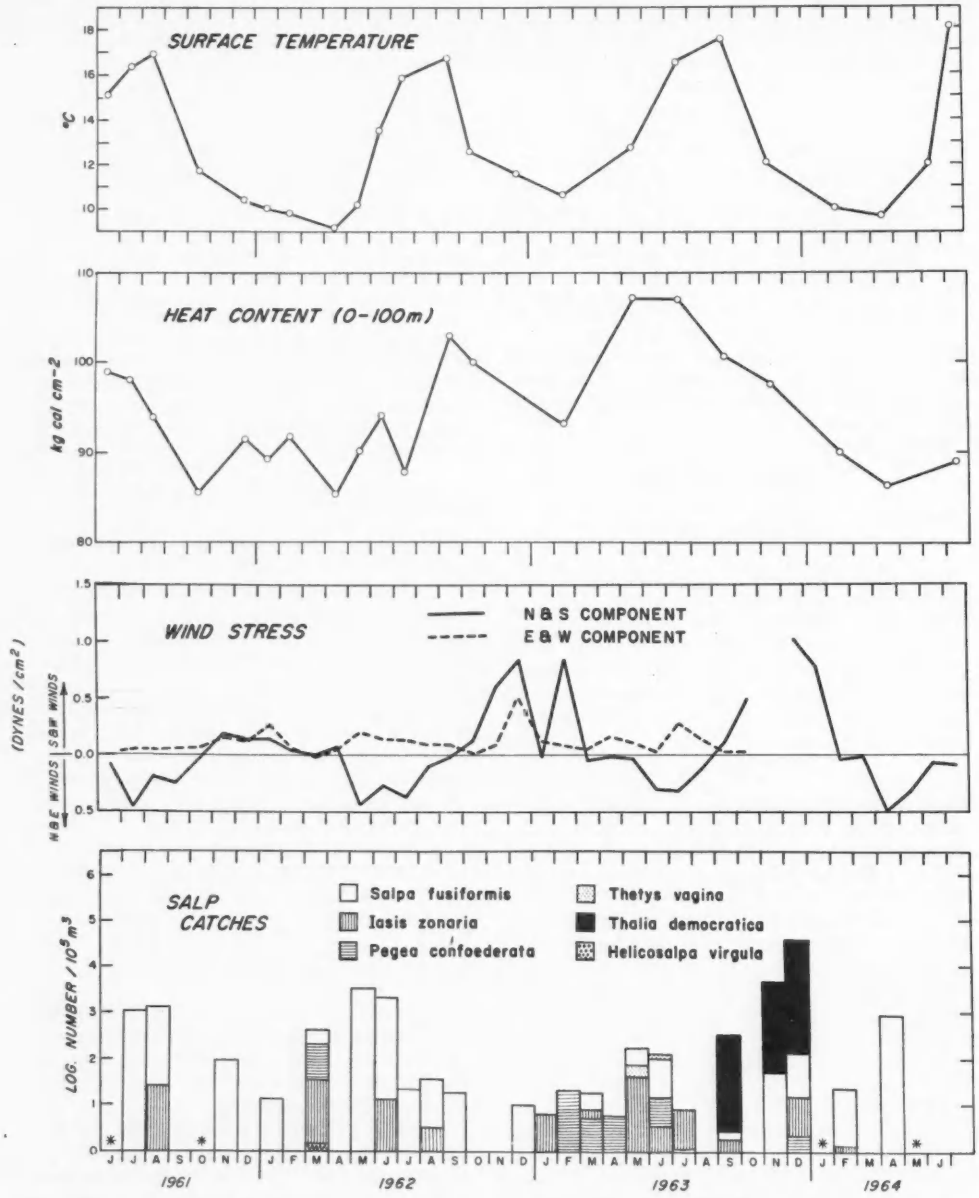

FIG. 2. Monthly variations of some ocean features and salp catches, 1961–64. Surface temperature is that at the station 65 miles off Newport. Heat content is that at the station 65 miles off Newport (data from Pattullo et al. 1969 except for 1961). The points for heat content on June 1961 and November 1963 and those for surface temperature on June 1961 and 1964 are from the station 45 miles off Newport. Wind Stress is calculated from monthly mean sea-level atmospheric pressure at 45°N, 125°W (data in part from Smith 1964). Salp catches are from midwater trawls. The logarithm of the catch of each species is plotted from the abscissa. Asterisks (*) denote months when no tows were made. Months are blank when tows were made but no salps were caught.

Pegea confoederata appeared irregularly throughout the winter and spring (December–June) (Fig. 2). It was collected off southern Oregon in March and June of 1962 and off central and northern Oregon in February, April, and June of 1963. Its frequency of occurrence was higher in 1963 than any other year.

THETYS VAGINA TILESIUS 1802

This cosmopolitan species was captured only five times, all in May and June of 1963. It was collected on every station line except the northern line, occurring between 25 and 5 miles offshore.

THALIA DEMOCRATICA (FORSKÅL) 1775

The occurrence of this form off Oregon represents a northern extension of its known range in the eastern Pacific. It is the most abundant species of salp south of 35° in the northeastern Pacific (Ritter 1905; Thompson 1948; Berner MS 1957).

Thalia democratica was collected only 12 times. All occurrences were in September, November, and December of 1963 (Fig. 2). When present, it was very numerous, and densities were much higher than found for any other salp. Maximum catches were 80 per m^3 in midwater trawls and 150 per m^3 in plankton nets.

HELICOSALPA VIRGULA (VOGT) 1854

Helicosalpa virgula, which usually has been collected in warm oceanic regions (Thompson 1948; Yount 1958), has not previously been reported in the northeastern Pacific Ocean. Two specimens were caught 45 miles off Coos Bay in March 1963.

Depth Distribution

In the over 200 samples made with opening–closing nets in the upper 1000 m, no salps were collected below 150 m. This indicates that salps off Oregon are generally epipelagic in their vertical distribution and are found where wind-driven ocean circulation is most pronounced.

Salps and Ocean Conditions

1963 was an unusual year during this study and provides evidence for intrusion of warmwater salps into Oregon waters. *Thalia democratica*, *Thetys vagina*, and *Helicosalpa virgula* were collected only during this year (Fig. 2). *Pegea confoederata* occurred more frequently during 1963 than in any other year. All these species are thought to be warmwater forms (Ritter 1905; Thompson 1948; Berner MS 1957; Yount 1958). Berner, for example, states that *T. democratica* is a warmwater form, often abundant south of 35°N off California in the northeastern Pacific.

Data on heat content in the upper 100 m (from Pattullo et al. 1969), but not surface temperature, shows that 1963 was an unusually warm year off Oregon (Fig. 2). Dodimead and Pickard (1967) also found that 1963 was a warm year: temperatures at the top of the halocline were generally warmer than average over a large region of the eastern subarctic Pacific. Wickett (1967, and unpublished data) calculated that Ekman transport to the south between 45° and 50°N in the northeastern Pacific was lower in 1963 than other years during our study. This resulted in a weakened California Current System and a greater possibility of transport of surface waters from central regions into Oregon waters. These annual differences suggest that the warmwater salps present in 1963 may be indicators of advection of water from the south or southwest.

Seasonal variations in wind direction from 1961 to 1964 (Fig. 2) were obvious. Northerly winds predominated in the summer, resulting in coastal upwelling (Smith et al. 1969); southerly winds predominated in the winter, resulting in a northerly and inshore movement of surface waters (Burt and Wyatt 1964). Highest catches of salps, mainly *S. fusiformis*, occurred during the summers of most years, when northerly winds prevailed. *Iasis zonaria* also occurred most frequently during the summer. The very high catches of *T. democratica* in the fall of 1963 coincided with a period of southerly wind stress. Likewise, *P. confoederata* usually occurred during the winter or just after periods of southerly winds and currents.

Although advection from warmer regions may explain the occurrence of some salp species off Oregon, it is not an equally tenable explanation for all species of salps. *Salpa fusiformis* and *I. zonaria* were found in Oregon waters all seasons of the year. High catches of these species were made during the summers, when northerly winds and upwelling prevailed, and in years other than 1963. Both of these species have wide latitudinal ranges that extend into temperate waters (Thompson 1948). They are perhaps the most likely species to have year-round resident populations off Oregon.

Salpa fusiformis is known to be a eurythermal species (Thompson 1948; Berner MS 1957). Off Scotland, *S. fusiformis* is common and the only salp that normally reproduces at these latitudes (Fraser 1949, 1962). Off Oregon *S. fusiformis* was found at surface temperatures ranging from 8 to 14 C and surface salinities from 30.5 to 33.5‰.

The variety of sizes, the occurrence of sexual as well as asexual stages, and stolon proliferation found in *S. fusiformis* and *I. zonaria* off Oregon are evidence for local reproduction and in situ changes in population number. Reproduction may be rapid and affect population fluctuations and patchiness. Braconnot (1963) obtained complete development of oozoids and liberation of chains of blastozoids in only 8–12 days in laboratory experiments with *T. democratica*. The fact that highest numbers of *S. fusiformis* and *I. zonaria* were found during the summer, especially in oceanic water, may be related to the pronounced heating of offshore surface waters during this season (Pattullo et al. 1969). Upwelling and the Columbia River plume influence phytoplankton production off Oregon during the summer (Anderson 1964; L. E. Small et al. unpublished data) and may also influence the reproduction and abundance of these species of salps.

Acknowledgments

This research was supported by National Science Foundation, GB-1588 and GB-5494, and the Atomic Energy Commission, AT(45-1)-1750, RLO 1750-64. We thank J. Yount for helping with salp identifications, L. Nielson for translating the French reference, and M. Silver and J. Pattullo for comments on the manuscript.

ANDERSON, G. C. 1964. The seasonal and geographic distribution of primary productivity off the Washington and Oregon coasts. Limnol. Oceanogr. 9: 284–302.

BERNER, L. D. MS 1957. Studies on the Thaliacea of the temperate Northeast Pacific Ocean. Ph.D. Thesis. Univ. of California, Los Angeles, Calif. 144 p.

BRACONNOT, J. C. 1963. Etude de cycle annuel des salpes et Dolioles en rade de Villefranche-sur-Mer. J. Cons. 29: 21–36.

BURT, W. V., AND B. WYATT. 1964. Drift bøttle observations of the Davidson Current off Oregon, p. 156–165. *In* K. Yoshida [ed.] Studies on oceanography. Univ. of Washington Press, Seattle, Wash.

DODIMEAD, A. J., AND G. L. PICKARD. 1967. Annual changes in the oceanic-coastal waters of the eastern Subarctic Pacific. J. Fish. Res. Bd. Canada 24: 2207–2227.

FOXTON, P. 1966. The distribution and life-history of *Salpa thompsoni* Foxton with observations on a related species, *Salpa gerlachei* Foxton. Discovery Rep. 34: 1–116.

FRASER, J. H. 1949. The distribution of Thaliacea (salps and doliolids) in Scottish waters, 1920–1939. Sci. Invest. Fish. Div. Scot. 1: 44 p.

FRASER, J. H. 1962. The role of ctenophores and salps in zooplankton production and standing crop. Rapp. Procès-Verbaux Réunions Cons. Perma. Int. Explor. Mer 153: 121–123.

HARDY, A. C. 1936. Observations on the uneven distribution of oceanic plankton. Discovery Rep. 11: 511–538.

HARDY, A. C., AND E. R. GUNTHER. 1935. The plankton of the South Georgia whaling grounds and adjacent waters, 1926–1927. Discovery Rep. 11: 1–456.

MCEWEN, G. F., M. W. JOHNSON, AND T. R. FOLSOM. 1954. A statistical analysis of the performance of the Folsom plankton sampler splitter, based upon test observation. Arch. Meterorol. Geophys. Bioklimatol. Ser. A, 6: 502–527.

PATTULLO, J. G., W. V. BURT, AND S. A. KULM. 1969. Oceanic heat content off Oregon: its variations and their causes. Limnol. Oceanogr. 14: 279–287.

PEARCY, W. G., AND L. T. HUBBARD, JR., 1964. A modification of the Isaacs-Kidd midwater trawl for sampling at different depths. Deep-Sea Res. 11: 263–264.

RITTER, W. E. 1905. The pelagic tunicata of the San Diego region, excepting the Larvacea. Univ. Calif. Publ. Zool. 2: 51–112.

SEWELL, R. B. S. 1953. The pelagic tunicata. Brit. Mus. [Natur. Hist.] John Murray Exped. 1933–34. Sci. Rep. 10: 1–90.

SMITH, R. L. 1964. An investigation of upwelling along the Oregon coast. Ph.D. Thesis. Oregon State Univ. Library, Corvallis, Oreg. 140 p.

SMITH, R. L., J. G. PATTULLO, AND R. K. LANE. 1966. An investigation of the early stage of upwelling along the Oregon coast. J. Geophys. Res. 71: 1135–1140.

THOMPSON, H. 1948. Pelagic tunicates of Australia. Melbourne Counc. Sci. Ind. Res. Australia. 196 p.

WICKETT, P. W. 1967. Ekman transport and zooplankton concentrations in the North Pacific Ocean. J. Fish. Res. Bd. Canada 24: 581–594.

YENTSCH, C. S., G. D. GRICE, AND A. D. HART. 1962. Some opening-closing devices for plankton nets operated by pressure, electrical and mechanical action. Rapp. Procès-Verbaux Réunions Cons. Perma. Int. Explor. Mer 153: 59–65.

YOUNT, J. L. 1958. Distribution and ecological aspects of Central Pacific Salpidae (Tunicata). Pac. Sci. 12: 111–130.

The Solubilizing Effect of Lysolecithin on the Extractability of Various Tissues of Rainbow Trout (*Salmo gairdneri*)

R. E. E. JONAS

Fisheries Research Board of Canada
Vancouver Laboratory, Vancouver, B.C.

JONAS, R. E. E. 1971. The solubilizing effect of lysolecithin on the extractability of various tissues of rainbow trout (*Salmo gairdneri*). J. Fish. Res. Bd. Canada 28: 1837–1840.

Liver homogenate treated with and without lysolecithin (LL) and centrifuged at 1600 g and the supernatant portion centrifuged again at 20,000 g showed disintegration of organelles with disruption of their membranes in the pellet fractions of that which was treated with LL, whereas the organelles of the others were normal. This was seen from the electron micrographs of the pellet fractions. The amino acid composition of the protein fraction of the white skeletal muscle soluble in 0.9% NaCl and of the larger fraction extractable in 0.9% NaCl with LL added were similar. The total nitrogen found in the supernatant fraction of brain, kidney, and liver homogenates reached approximately 44, 59, and 63% in 0.9% NaCl and ≈88, 95, and 89% in 0.9% NaCl containing 4 mg/ml LL; whereas the total N present in heart muscle and white muscle homogenates reached approximately 39 and 31% in 0.9% NaCl and ≈61 and 51% in 0.9% NaCl containing 4 mg/ml LL. LL destroyed the ability of liver tissue and liver mitochondria to oxidize ^{14}C palmitate. It was concluded that the effect of LL in increasing the amount of protein extractable from fish tissue homogenates arises from its ability to lower surface tension and disrupt membranes and not by affecting protein solubility.

JONAS, R. E. E. 1971. The solubilizing effect of lysolecithin on the extractability of various tissues of rainbow trout (*Salmo gairdneri*). J. Fish. Res. Bd. Canada 28: 1837–1840.

Un homogénat de foie traité avec et sans lysolécithine (LL) fut centrifugé à 1600 g. La portion surnageante, centrifugée de nouveau à 20,000 g, révèle, dans ses fractions boulette traitées à la LL, une désintégration des organites et une destruction des membranes, alors que les organites des fractions nontraités demeurent normales. Les micrographies électroniques des fractions boulette confirment ce fait. La composition en acides aminés de la fraction protéique du muscle squelettique blanc, soluble dans le NaCl à 0.9%, est semblable à celle de la fraction, plus considérable, extractible au NaCl à 0.9% auquel a été ajouté la LL. Le N total de la fraction surnageante d'homogénats de cerveau, de rein et de foie atteint environ 44, 59, et 63% dans le NaCl à 0.9% et ≈88, 95, et 89% dans le NaCl à 0.9% contenant 4 mg/ml de LL. D'autre part, le N total d'homogénats de muscle cardiaque et de muscle blanc atteint environ 39 et 31% dans le NaCl à 0.9% et ≈61 et 51% dans le NaCl à 0.9% additionné de 4 mg/ml de LL. La LL annihile la capacité du tissu et des mitochondries hépatiques d'oxyder le ^{14}C palmitate. L'auteur en conclut que la LL augmente la fraction protéique extractible des homogénats de tissus de poisson grâce à sa capacité d'abaisser la tension superficielle et de détruire les membranes, et non par changement de solubilité des protéines.

Received April 5, 1971

CURRENT theories of membrane permeability have focused attention on the cytochemical involvement of lysolecithin (LL) in membrane fusion and lysis (Lucy 1970; Poole et al. 1970) and on its possible role in the action of enzymes and steroids (Kellaway and Saunders 1967; Ferber et al. 1968). The property of LL in solubilizing the homogenate of the white muscle of fish was the subject of an earlier paper (Jonas 1968). The present investigation is a continuation of the above study, and was undertaken to examine the nature of the additional protein extracted as a result of the action of LL and to extend the study of its action on some of the other tissues and organelles of rainbow trout (*Salmo gairdneri*) in an attempt to elucidate the function of LL in solubilizing fish muscle homogenates.

Printed in Canada (J2112)

Experimental

FISH

Commercial hatchery-raised rainbow trout, weighing approximately 250 g, were used in these experiments.

Chemicals

Lysolecithin was obtained from Nutritional Biochemicals Corporation, Cleveland, Ohio. Reagents used in amino acid (AA) analysis were those recommended by Beckman Instruments Inc., Palo Alto, California. ^{14}C-labelled substrates were prepared as described previously (Bilinski and Jonas 1970). All other chemicals used were the purest grades available commercially.

Homogenization and Separation of Particulate Fractions

100 mg of muscle or organ tissue from freshly killed rainbow trout was cut into small pieces and placed in two test tubes; 2.0 ml 0.9% NaCl was added to both tubes. The tissue was homogenized with a modified Potter Elvejhem type homogenizer (with a rigidly supported plastic pestle) having an automatic timing device for two half-minute periods (Umbreit et al. 1964). The whole operation was carried out at 0 C. 1.0 ml 0.9% NaCl was added to one tube (control), and 1.0 ml 0.9% NaCl containing 12 mg/ml LL was added to the other tube, so that 3.0 ml of test-sample solution contained 4 mg/ml LL. The tubes were stoppered, after displacing the air by nitrogen gas, and incubated in a water bath at 35 C with constant shaking. At the end of 1 hr, the tubes were centrifuged at 1600 *g* and separated into pellet and supernate fractions by decantation. As a result of agglutination, the pellet fraction contained most of the mitochondria sedimented with nuclei, whole undisrupted cells, erythrocytes, some lysosomes and cell debris. The microsomes with a few mitochondria could be found in the supernatant (Umbreit et al. 1964). In comparing the solubilization of various tissues by LL, skeletal muscle, heart muscle, liver, kidney, and brain tissues were used.

The homogenization technique described above was followed to be consistent with the experiment reported earlier (Jonas 1968). A difference in the technique and the type of homogenizer used could change the components of the fractions obtained.

Electron Microscopy of Liver Homogenate With and Without LL Treatment

Preparation of tissue for sampling

Two test tubes containing 100 mg liver tissue homogenate, one with LL (4 mg/ml) and the other without (prepared as described previously), were incubated at 35 C for 1 hr and centrifuged at 1600 g. The supernatant solution from both tubes was decanted into two test tubes and recentrifuged at 20,000 g for 1 hr. Samples were taken from the pellet and supernate fractions after each centrifugation for electron microsocopic examination. Part of the control sample pellet obtained after the first centrifugation was placed on a microscope slide and allowed to react with LL (4 mg/ml LL in 0.9% NaCl). At the end of 15 min most of the fluid was blotted off the slide and the LL-exposed pellet taken for microscopic examination. Since electron micrographs of the supernates did not yield useful information, these have been omitted.

Preparation of sample for microscopic examination

The samples were fixed with glutaraldehyde and postfixed with Osmium tetroxide, embedded in Epon 812 (Luft 1961), and thin sections of about 500–600 Å were stained with uranyl acetate and lead citrate (Weintraub and Ragetli 1970).

Preparation of soluble protein fraction for AA analysis

From a 20.0-ml aliquot of the supernatant solution of white skeletal muscle, prepared as described previously, the protein was precipitated by addition of 10.0 ml 30% trichloracetic acid (TCA). The mixture was then centrifuged at 12,000 g for 10 min. The clear supernate, free from protein, was discarded and the residue washed with 100, 10, and 10 ml of ethyl ether, respectively, to remove any trace of TCA. Finally it was washed with 10.0 ml acetone and partially dried under flowing nitrogen gas. The residue was then further dried in a vacuum desiccator containing potassium hydroxide pellets. Aliquots of the powdery residue were used for AA analysis and the determination of total N. Two sets of residues were prepared: one set in which the tissue had been treated with LL and a second in the preparation of which LL was omitted (control).

Amino acid analysis

The sample residues were hydrolyzed for 24, 48, and 72 hr with 6 N HCl, as described by Moore and Stein (1963), except that the mixture was thoroughly flushed with nitrogen gas. The amino acids that slowly decompose on hydrolysis were calculated by extrapolation to zero time, the highest values were used for those that are slowly hydrolyzed, and mean values were used for others (Mahowald et al. 1962; Tsuyuki and Ronald 1971). The analyses were carried out with a Beckman Amino Acid Analyzer Model 120B, using Model 125B Digital Integrator. N determinations were carried out by the micro-Kjeldahl method of Steyermark (1951). N values were multiplied by a factor of 6.25 for conversion to protein.

Fatty acid oxidation

An experiment was performed to determine the effect of LL on fatty acid oxidation by the method described previously (Bilinski and Jonas 1970). A brief description is given below. K-palmitate-1-^{14}C (0.1 mM) was used as substrate in the standard incubation medium consisting of $NaKHPO_4$ buffer, *p*H 7.4, 20 mM; KCl, 50 mM; $MgCl_2$, 7.5 mM; ATP, 1.5 mM; α-keto-glutarate, 0.5 mM; CoA, 0.1 mM; Carnitine, 1.0 mM, in a total volume of 2.0 ml. Mitochondrial suspension (0.25 ml, 0.5 mg N) was introduced into the main compartment of one set of flasks and 200 mg liver tissue was added to another set. Control flasks contained no LL, but LL was added to test flasks to give a final concentration of 4 mg/ml. The experiment was done in duplicate.

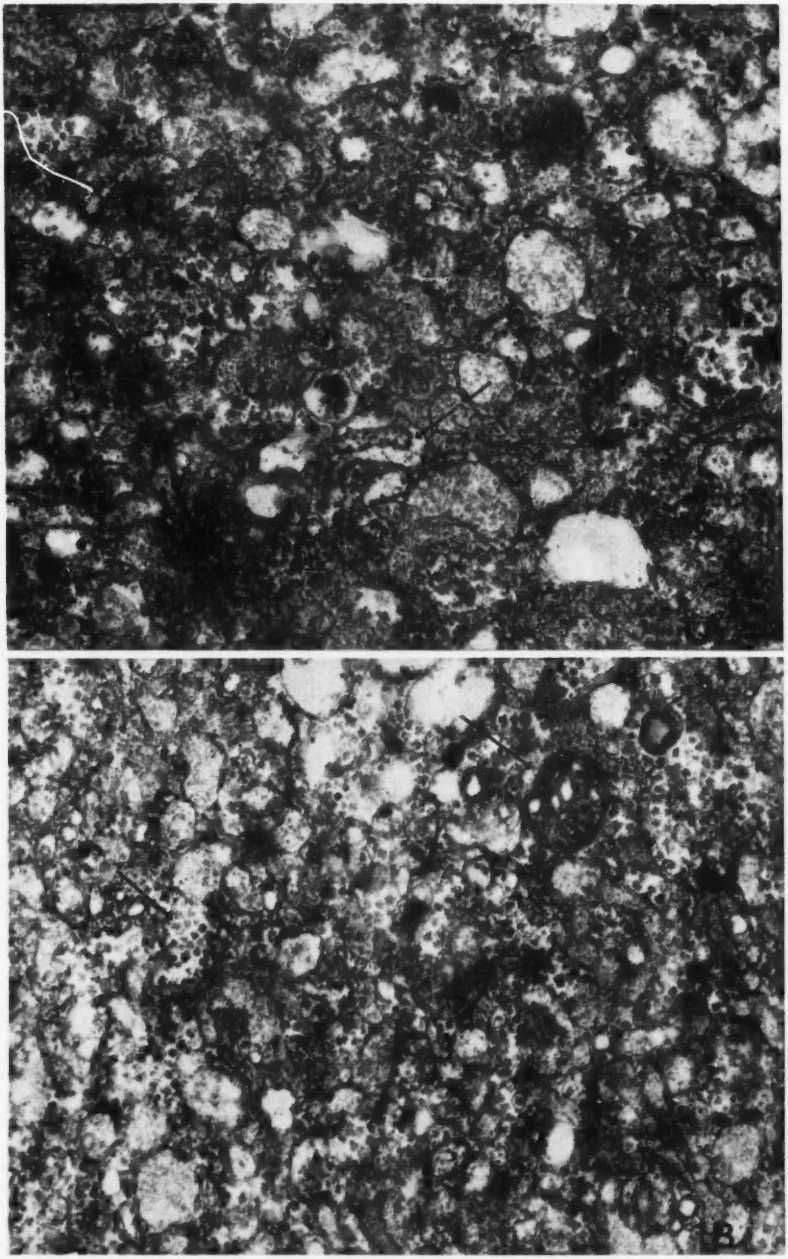

FIG. 1. Pellet fraction from second centrifugation of untreated liver homogenate incubated for 1 hr (control). (A) Granular endoplasmic reticular fragment containing ribsomes. ×27,000. (B) Mitochondrion and glycogen rosettes. ×20,000.

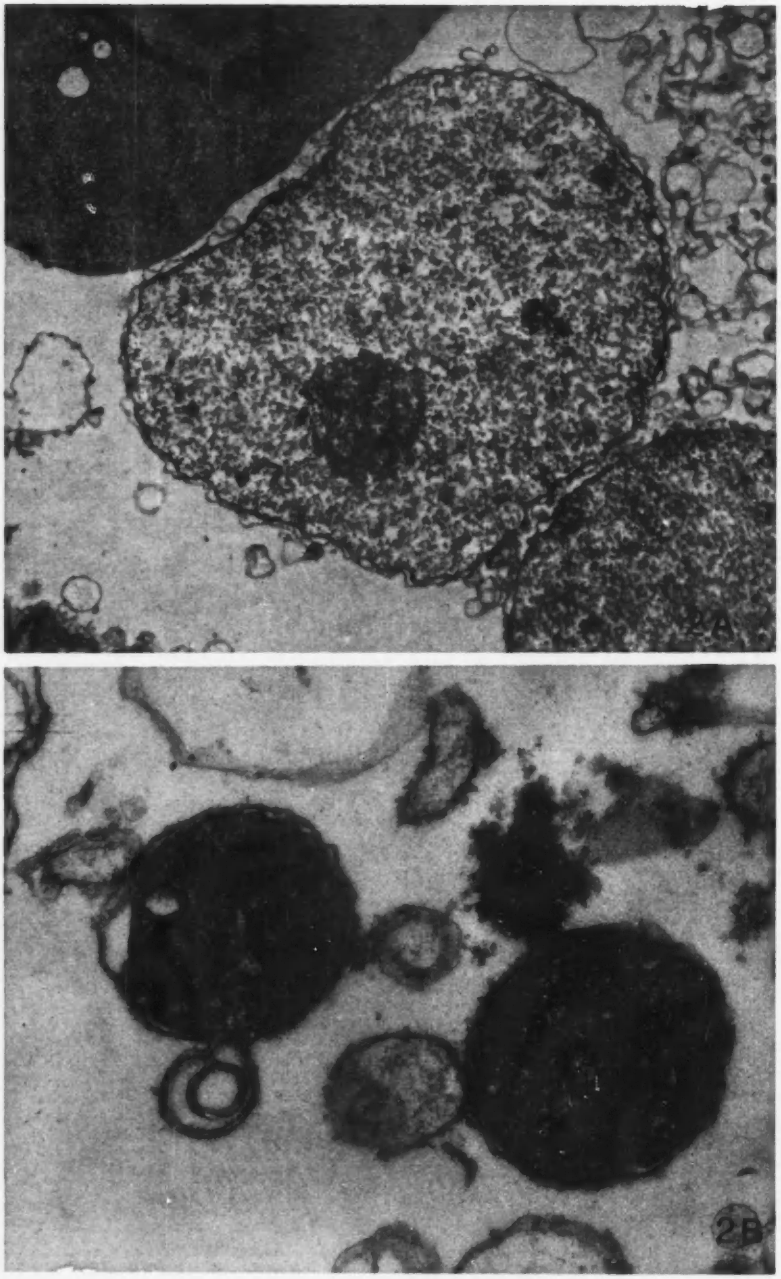

FIG. 2. Pellet from first centrifugation of untreated liver homogenate incubated for 1 hr (control). (A) Nucleus containing nucleolus and part of a nucleated erythrocyte. ×12,000. (B) Mitochondria. ×46,000.

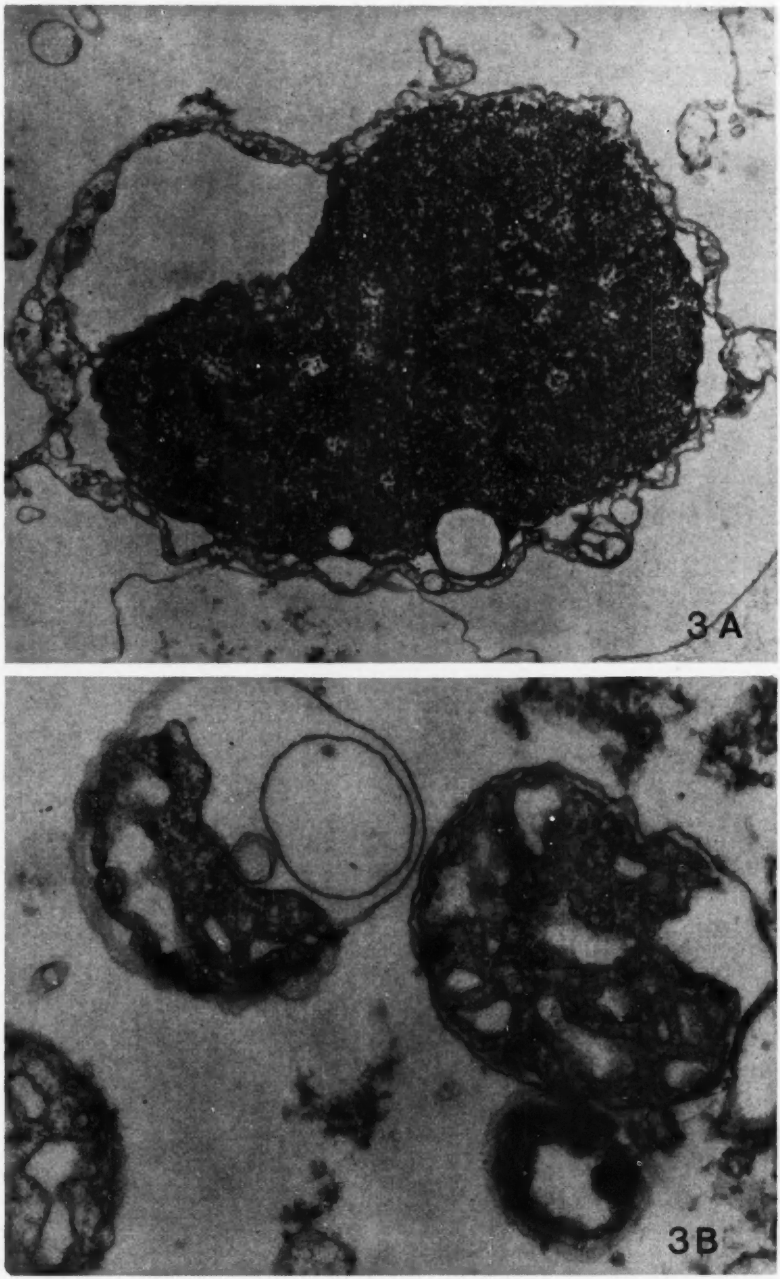

FIG. 3. Pellet from first centrifugation of liver homogenate (control) exposed to LL for 15 min showing the beginning of membrane dissolution and some loss of internal contents. (A) Remains of a LL damaged nucleus. ×12,000. (B) Remains of LL damaged mitochondria. ×46,000.

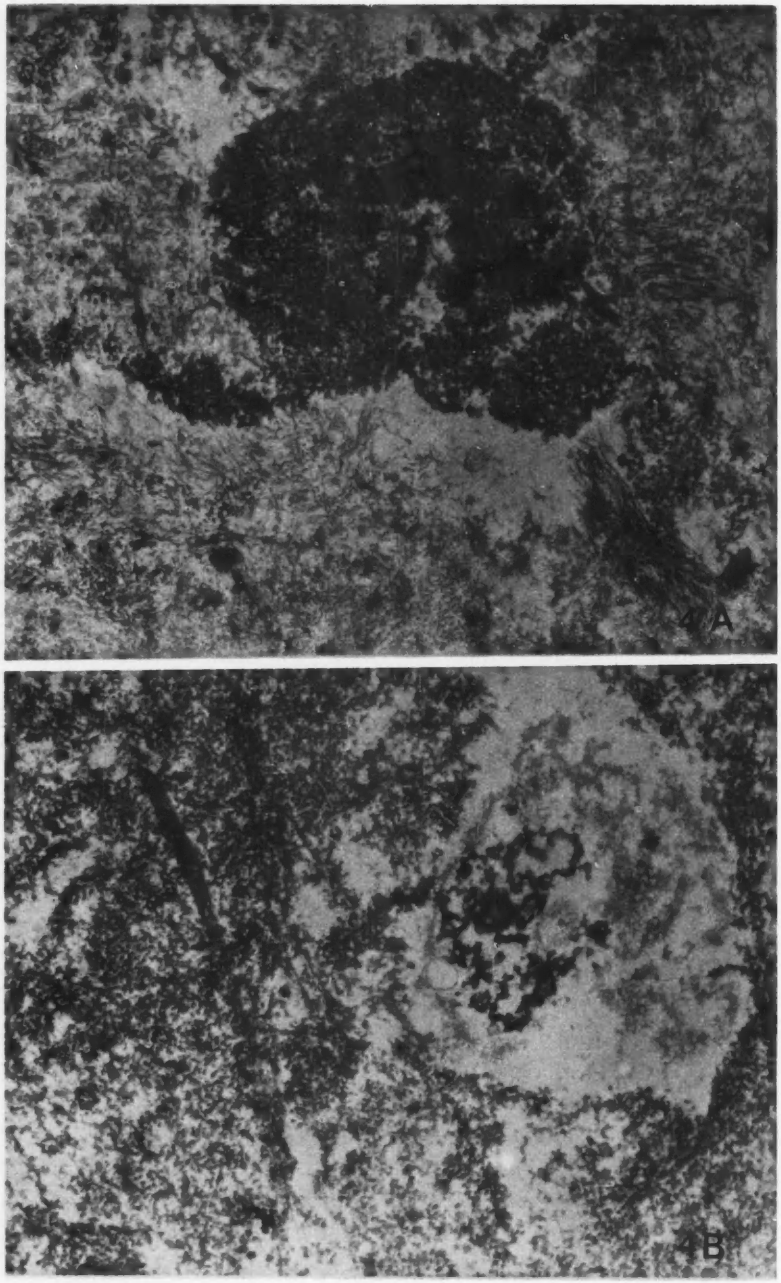

FIG. 4. Pellet from first centrifugation of liver homogenate incubated with LL for 1 hr, showing the complete loss of membranes around the nucleus. (A) Granular remnants of a nucleus. ×20,000. (B) Remains of what appears to be nucleolus with somewhat electron transparent granules of a nucleus. ×20,000.

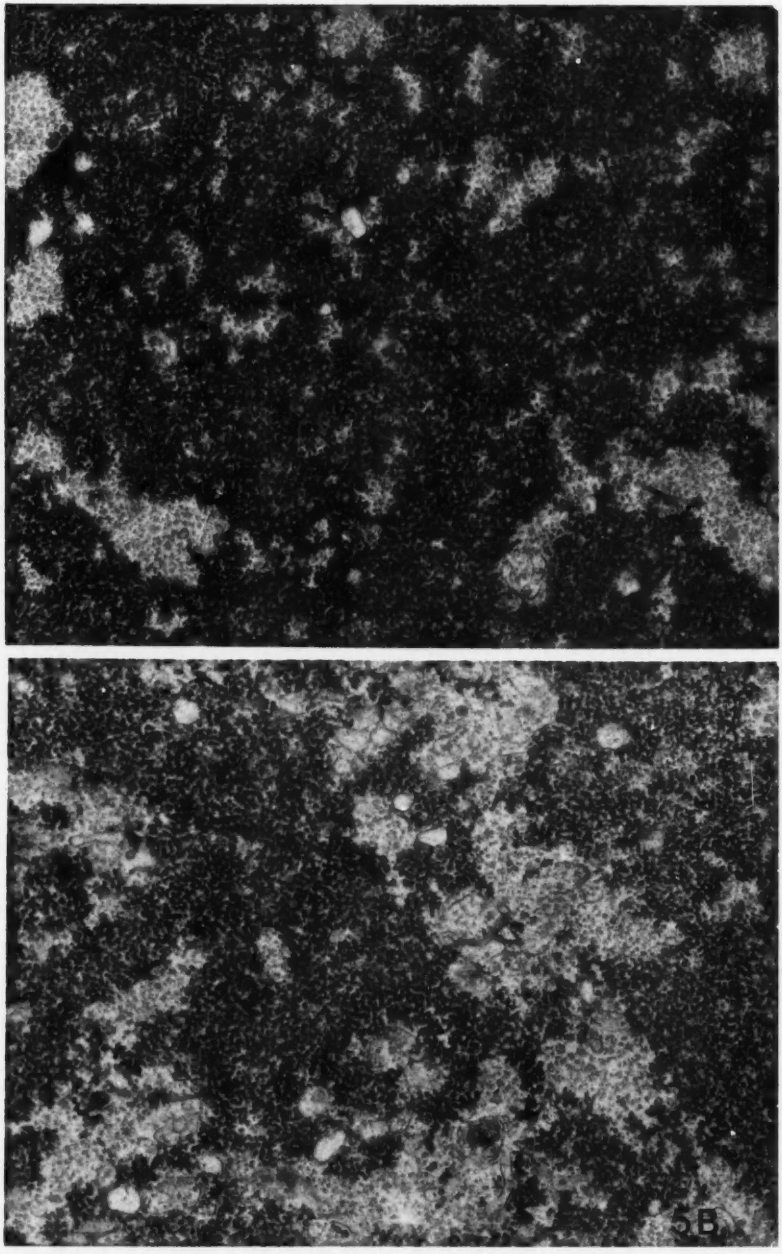

FIG. 5. Pellet from second centrifugation of liver homogenate incubated with LL for 1 hr showing utter destruction of all larger organelles. (A) Somewhat dissolved trace of rough endoplasmic reticular membrane with ribosomelike granules. ×20,000. (B) Trace remnants of membranes, electron-dense, and light ribosomelike bodies and unidentifiable debris. ×20,000.

TABLE 1. Amino acid composition of protein in the supernate fraction of white muscle homogenate in 0.9% NaCl (amino acid residues: g per 100 g protein).

	Control	Control + LL	Difference (±)
Lysine	13.07	12.64	0.43
Histidine	4.55	3.98	0.57
Arginine	7.43	7.84	0.41
Aspartic acid	10.71	10.31	0.40
Threonine	4.25	5.19	0.94
Serine	3.62	3.41	0.21
Glutamic acid	11.21	11.74	0.53
Proline	2.67	2.70	0.03
Glycine	5.35	4.46	0.99
Alanine	6.64	5.83	0.81
½ Cystine	–	–	–
Valine	5.55	5.14	0.41
Methionine	2.85	2.82	0.03
Isoleucine	5.36	4.98	0.38
Leucine	8.31	8.34	0.03
Tyrosine	3.03	3.10	0.07
Phenylalanine	6.60	6.01	0.59
Tryptophan	–	–	–
Total	101.53	98.49	

TABLE 2. Action of LL on fatty acid oxidation.

Tissue	$^{14}CO_2$ per mg N/hr at 25 C (*nmoles*) Range	Mean
Liver slices (untreated)	35.6–40.5	38.05
Liver slices (treated with LL)	Nil	–
Liver mitochondria (untreated)	63.80–65.50	64.65
Liver mitochondria (treated with LL)	Nil	–

TABLE 3. Lysolecithin effects on tissue homogenates.

Tissue[a]	% N in supernate of 100 mg homogenate in 3.0 ml soln. Solubilized by 0.9% NaCl	Solubilized by 0.9% NaCl +LL	Increase in supernate N caused by LL	No. fish used
White skeletal muscle	31.0 ±0.51	51.20±0.82	20.20	3
Heart muscle	39.39±0.58	61.27±0.61	21.88	4
Liver tissue	62.94±2.23	88.87±2.44	25.06	2
Kidney tissue	58.58±1.18	94.81±0.72	36.23	2
Brain tissue	44.26±0.31	88.04±0.13	43.78	4

[a]Values reported represent the average of four separate determinations and the standard deviation.

Results and Discussion

Electron Micrographs of LL-Treated Liver Tissue

To avoid the insertion of too many micrographs, only a selected few that illustrate the lysing action of LL are included. The control sample pellet obtained after the first centrigufation (Fig. 2) showed erythrocytes, nuclei, mitochondria, lysosomelike bodies, and cell debris (Umbreit et al. 1964). The pellet fraction obtained from the second centrifugation (Fig. 1) showed microsomes, glycogen (rosettes), endoplasmic reticulum containing ribosomes as electron-dense particles, and very few mitochondria. The portion of the pellet from the first centrifugation exposed to LL for 15 min showed the solubilizing effect of LL on the membranes covering the mitochondria and nuclei (Fig. 3) with some loss of internal material. Lysosomelike bodies appeared to be less electron-dense. Figure 4 shows the destructive effect of LL on membrane structures that have been exposed to LL for 1 hr. Remnants of what appear to be nuclei in different stages of digestion are shown. Figure 5 shows such extreme states of lysis that intact larger organelles are no longer identifiable. Microsomes and other microbodies seem less electron-dense in some areas, probably indicating a dissolution of their entities. The increase in protein N obtained in the supernatant solution of the tissue homogenate containing LL over control (Table 3) is therefore due to proteins released by the organelles. The lytic power of lysosomal enzymes, as a result of the destruction of lysosomal membrane, could possibly enhance the total effectiveness of the membrane-dissolving process.

AA Composition of the Soluble Protein Fraction

The AA composition of the fluid protein released by homogenization of the control and test samples before LL addition could be identical. Since a large portion of the fluid protein present in the homogenate originally came from rupture of cells and organelles, the AA composition of the fluid protein present in the unbroken cells and organelles is unlikely to be very different. If LL acts by rupturing membrane structure, though the quantity of fluid protein obtained through this action would be larger, the AA composition of the total fluid protein could remain similar.

The AA composition of the two soluble proteins shown in Table 1 are similar. The largest variation (0.5–1.0 g AA residues/100 g protein) occurs only for histidine, threonine, glutamic acid, glycine, alanine, and phenylalanine. Thus, the fact that there is little difference between the AA composition of the soluble protein of the control and of the tissue treated with LL may add further support to the theory that LL acts by disrupting membrane structure (Small 1968) rather than by affecting the solubility of certain types of protein.

Action of LL on Fatty Acid Oxidation

Whereas 38.05 and 64.65 nmoles of substrate were converted to $^{14}CO_2$ per mg N per hr by liver tissue slices and liver mitochondria without added LL, none was formed in flasks containing added LL (Table 2). Since mitochondria are lysed by LL and since it is known that the enzymes of fatty acid oxidation require the integrity of the mitochondrial unit to carry out fatty acid oxidation (Bilinski and Jonas 1970), it appears that even in tissue slices LL disrupts them.

Solubilization of Various Tissues by LL

The magnitude of the increase in supernate N caused by LL solubilization is affected by the softness and frailty of the tissues in the two bulk groups, muscle versus organ tissue (Table 3). Thus, muscle tissues (white muscle and heart muscle) are less solubilized than tissues of the organs (liver, kidney, and brain). The property of contractility, which is highly developed in the muscles, require fibrous proteins for their function. These proteins probably account for their toughness and lesser solubilization, in contrast with the softness and higher solubilization of the organ tissues by LL.

The concentrations of LL used in these experiments are in excess of those likely to be found in tissues normally. However, it is possible that small amounts of LL formed under physiological conditions, together with enzymatic cytochemical localization, could be far more effective than higher concentrations added externally. In many instances, only the addition of such higher concentrations can demonstrate in vitro what takes place normally or abnormally in vivo (McArdle et al. 1960).

Though there are differences of opinion regarding the unit membrane of Davson and Danielli (1952) and Robertson (1964) and the repeating units of nesting lipoprotein continua of Vanderkooi and Green (1970), both theories are agreed on the hydrophobic bonding of phospholipid (PL) to protein. According to Day and Levy (1969), a principal function of PL in living organisms is to serve as a molecular "glue" to build many of the cellular organelles, such as membranes. Ample evidence has been presented by Green and Perdue (1966) and Stein (1967) that PL are in a state of dynamic

exchange equilibrium. The soluble amphiphilic nature of LL renders it intensely surface-active, tending to concentrate at the polar nonpolar interphase with the charged hydrophilic portion in the aqueous and the hydrophobic chains inserted into the nonpolar lipid or lipoprotein phase. Hence, LL exchanging with membrane PL lowering the consistency of the "glue" can disturb the molecular arrangements within the membrane, facilitating rupture (Stein 1967; Poole et al. 1970). Therefore, the increase in soluble protein N in the supernates of homogenates containing LL could be caused not by change in protein solubility but by rupture of cell membranes and an increase in intracellular fluid as evidenced by electron micrographs mentioned earlier. It must be emphasized, that, although the above observations provide an explanation for the action of LL in tissue homogenates, no attempt has yet been made to examine in detail the complex phenomena accompanying membrane stability and structure involving other lipids, enzymes, bile, cholesterol (Small 1968), ionic groups, and other biochemicals and factors imperfectly perceived at present. However, it is possible that lysis and fusion of cells by a simple chemical that occurs naturally in the animal body could have vital significance in tissue growth, disease, and decay.

Acknowledgments

The author expresses his appreciation to Dr E. Bilinski for his advice and guidance throughout the progress of this work; to Mr A. P. Ronald for technical help in the use of the Beckman Amino Acid Analyzer; to Dr R. J. Bose for his discussions on membrane structures; and to Dr M. Weintraub, Research Station, Canada Agriculture, Vancouver, B.C., for the production and interpretation of the electron micrographs.

BILINSKI, E., AND R. E. E. JONAS. 1970. Effects of coenzyme A and carnitine on fatty acid oxidation by rainbow trout mitochondria. J. Fish. Res. Bd. Canada 27: 857–864.

DAVSON, H., AND J. F. DANIELLI. 1952. The permeability of natural membranes, 2nd ed. Cambridge Univ. Press, Cambridge and New York. 365 p.

DAY, C. E., AND R. S. LEVY. 1969. A generalized functional role for phospholipids. J. Theor. Biol. 22: 541–542.

FERBER, E., P. G. MUNDER, A. KOHLSCHUETTER, AND H. FISHER. 1968. Lysolecithin metabolizing enzyme of intact erythrocytes and modified stroma. Folia Haematol. (Leipzig) 90: 224–232.

GREEN, D. E. AND J. F. PERDUE. 1966. Membranes as expressions of repeating units. Proc. Nat. Acad. Sci. 55: 1295–1302.

JONAS, R. E. E. 1968. Dissolution of fish muscle homogenates by lysolecithin. J. Fish. Res. Bd. Canada 25: 2157–2164.

KELLAWAY, I. W., AND L. SAUNDERS. 1967. The solubilization of some steroids by phosphatidyl choline and lysophosphatidyl choline. Biochim. Biophys. Acta 144: 145–148.

LUCY, J. A. 1970. The fusion of biological membranes. Nature 227: 815–817.

LUFT, J. H. 1961. Improvements in epoxy resin embedding methods. J. Biophys. Biochem. Cytol. 9: 409–414.

MAHOWALD, T. A., E. A. NOLTMANN, AND S. A. KUBY. 1962. Studies on adenosine triphosphate transphosphorylases. J. Biol. Chem. 237: 1138–1145.

MCARDLE, B., R. H. S. THOMPSON, AND G. R. WEBSTER. 1960. The action of lysolecithin and of snake venom on whole-cell preparations of brain, muscle and liver. J. Neurochem. 5: 135–144.

MOORE, S., AND W. H. STEIN. 1963. Chromatographic determination of amino acids by the use of automatic recording equipment. *In* S. P. Colowick and N. O. Kaplan [ed.] Methods in enzymology. Vol. 6. Academic Press, Inc., New York, N.Y. 819 p.

POOLE, A. R., J. I. HOWELL, AND J. A. LUCY. 1970. Lysolecithin and cell fusion. Nature 227: 810–813.

ROBERTSON, J. D. 1964. Unit membranes. A review with recent new studies of experimental alterations and a new subunit structure in synaptic membranes, p. 1–81. *In* M. Locke [ed.] Cellular membranes in development. Academic Press, Inc., New York, N.Y.

SMALL, D. M. 1968. A classification of biologic lipids based upon their interaction in aqueous systems. J. Amer. Oil Chem. Soc. 45: 108–117.

STEIN, W. D. 1967. The movement of molecules across cell membranes. Academic Press, Inc., New York and London, 369 p.

STEYERMARK, A. 1951. Quantitative organic microanalysis. Blackiston Co., Toronto, Ont. 389 p.

TSUYUKI, H., AND A. P. RONALD. 1971. Molecular basis for multiplicity of Pacific salmon hemoglobins: evidence for *in vivo* existence of molecular species with up to four different polypeptides. Comp. Biochem. Physiol. 39: 503–522.

UMBREIT, W. W., R. H. BURRIS, AND J. F. STAUFFER. 1964. Manometric techniques. Burgess Publishing Co., Minneapolis, Minnesota. p. 159–192.

VANDERKOOI, G., AND D. E. GREEN. 1970. Biological membrane structure. I. The protein crystal model for membranes. Proc. Nat. Acad. Sci. 66: 615–621.

WEINTRAUB, M., AND H. W. J. RAGETLI. 1970. Electron microscopy of the bean and cowpea strains of southern bean mosaic virus within leaf cells. J. Ultrastruct. Res. 32: 167–189.

Chloramine Toxicity to the Amphipod *Gammarus pseudolimnaeus* and the Fathead Minnow (*Pimephales promelas*)

JOHN W. ARTHUR AND JOHN G. EATON

U.S. Environmental Protection Agency
National Water Quality Laboratory, Duluth, Minnesota 55804

ARTHUR, J. W., AND J. G. EATON. 1971. Chloramine toxicity to the amphipod *Gammarus pseudolimnaeus* and the fathead minnow (*Pimephales promelas*). J. Fish. Res. Bd. Canada 28: 1841–1845.

The amphipod *Gammarus pseudolimnaeus* was subjected to 96-hr and 15-week exposures, and the fathead minnow (*Pimephales promelas*) to a 21-week exposure, to various chloramine concentrations under continuous-flow conditions. The most marked sublethal effects were reductions in the number of young produced by the amphipod and in egg production by the minnow. The 96-hr median tolerance limit for the amphipod was 220 μg/liter total chloramine. Fathead minnows in the long-term study were all killed at the highest concentration, 154 μg/liter total chloramine, within 3 days. The lowest measured total chloramine concentration in the long-term tests having no significant effect was <3.4 μg/liter for the amphipod and 16.5 μg/liter for the fathead minnow.

ARTHUR, J. W., AND J. G. EATON. 1971. Chloramine toxicity to the amphipod *Gammarus pseudolimnaeus* and the fathead minnow (*Pimephales promelas*). J. Fish. Res. Bd. Canada 28: 1841–1845.

Nous avons exposé des amphipodes *Gammarus pseudolimnaeus* à diverses teneurs en chloramine à flot continu pendant des périodes de 96 h et 15 semaines. Des ménés à grosse tête *Pimephales promelas* ont subi le même traitement pendant 21 semaines. L'effet subléthal le plus marqué fut une réduction de la production de jeunes chez les amphipodes et d'oeufs chez les ménés. Au cours de l'expérience de 96 h, la médiane de la limite de tolérance des amphipodes fut de 220 μg/litre de chloramine totale. Au cours de l'expérience de 21 semaines, tous les ménés moururent en l'espace de 3 jours lorsque exposés à la teneur maximale de 154 μg/litre de chloramine totale. La teneur la plus basse de chloramine totale qui, au cours des essais à long terme, n'eut pas d'effet appréciable fut de <3.4 μg/litre pour les amphipodes et 16.5 μg/litre pour les ménés à grosse tête.

Received February 16, 1971

CHLORINATION of public water supplies, sewage, and industrial effluents has become a widespread disinfection practice. The resulting toxicity of tap water in many localities is well known to most fish culturists. Recent reports show that chlorination of sewage (Tsai 1970: J. A. Zillich personal communication) and power-plant effluents (Hamilton et al. 1970) can produce localized damaging effects on aquatic life in natural habitats.

Laboratory-derived information on chlorine toxicity to aquatic life has previously been collected only during short-term exposures. The toxicities of free chlorine and chloramines to coho salmon (*Oncorhynchus kisutch*) in exposures up to 20 hr (Holland et al. 1960) and to rainbow trout (*Salmo gairdneri*) in 7-day exposures (Merkens 1958) were found to be of the same order of magnitude, and killed fish at concentrations ranging from 1 to less than 0.1 mg/liter. No information could be obtained from the literature on laboratory exposures of aquatic invertebrates to chlorine.

The objective of this study was to determine the short-term and long-term (chronic) toxicities of chloramines to a representative invertebrate and fish species, including observations of mortality, growth, and reproductive ability. Test animals were the amphipod *Gammarus pseudolimnaeus* Bousfield and the fathead minnow (*Pimephales promelas* Rafinesque). For the chronic tests, each species was exposed continuously to various chloramine concentrations for nearly a complete life cycle.

Materials and Methods

DILUTER AND TEST APPARATUS

The source of chlorine was the Duluth, Minnesota, potable water supply. Water is taken directly from Lake Superior into Duluth's pumping station, where filtration

Printed in Canada (J2049)

or settling treatment takes place. Free chlorine and ammonia in an approximate ratio of 3:1 are added to the water as it passes through the plant. The free chlorine is sufficient to produce a chloramine concentration of approximately 1 mg/liter.

A modified proportional diluter (Mount and Brungs 1967) served as the water-delivery system. Untreated Lake Superior water was piped directly into the laboratory and, via a headbox, flowed into the diluent water-containing cells of the diluter. Tap water containing chloramines entered a second headbox and flowed into the toxicant-bearing cells. A neoprene and rubber-coated solenoid valve controlled water flow to the diluter from each headbox. A dilution ratio of approximately 2:1 resulted in measured tank values ranging from about 200 to just under 4 μg/liter of total chloramines. Each time the diluter emptied, 600 ml of each test concentration and control water were delivered to a flow-splitting cell. From this cell 200 ml were supplied to each of two 5-gal tanks holding 15 liters (adults), and 100 ml to each of two 2-gal tanks (progeny) holding 7 liters. Rates of flow to the 5-and 2- gal tanks were 60–70 and 30–35 ml/min, respectively. Durotest (Optima FS) and wide spectrum Grow-lux fluorescent tubes together provided approximately 50–80 and 130–150 ft-c illumination at the water's surface for the 5- and 2-gal tanks, respectively.

Biological Methods

The amphipods and fathead minnows used in the tests were obtained from cultures maintained at this laboratory. Standard procedures (American Public Health Association 1965) were followed for determining the 96-hr median tolerance limits for amphipods.

The long-term study on the amphipod was conducted from August 26, 1969, to December 31, 1970. Twenty animals approximately 1 month old were placed into each 5-gal tank and fed maple and aspen leaves presoaked in diluent water. The test temperature was 17 ± 1 C, and the photoperiod initially was set for light conditions at Evansville, Indiana (representing light conditions for the middle of the continental United States). When the amphipods became adult in size and started mating (late October 1969), the photoperiod was changed to a, constant 16-hr day. The animals produced young from mid-November until the test was ended. Most of the newly hatched young were captured by temporarily isolating gravid females in 600-ml beakers containing the respective test waters.

The juvenile fathead minnows used to start the chronic study were 3 months old and ranged from 33 to 50 mm long; mean wet weight was 0.46 g. The test was conducted from January 14, 1970, to June 12, 1970. Ten individuals were assigned randomly to each 5-gal test chamber. The temperature was maintained at 23 ± 1 C and the photoperiod at 16 hr of light each day. Daily the fish were fed ⅛-inch Oregon Moist pellets, which were stored in a freezer. Since food remaining in the test tanks temporarily lowered the chloramine concentration by as much as 50%, excess food was removed by siphoning 2 hr after the fish were fed. The regular diet was supplemented once or twice a week with live *Daphnia*.

Procedures employed during spawning were similar to those described by Mount (1968). The spawning sites provided to the fish were 6-inch-long, semicircular sections of concrete–asbestos water pipe (irrigation tiles); one tile was placed in each test tank with the concave surface downward. Eggs were attached to the undersides of these tunnel-like substrates during spawning and were immediately fertilized. Between 10:00 and 12:00 AM each day, 25 or 50 unbroken eggs were placed in gently moving egg-incubation cups and the remainder discarded after counting, or (weekends) the eggs on the tiles were counted and discarded. Approximately 1 month after spawning started, the number of sexually mature males, as judged by secondary sexual characteristics and aggressive behavior, was reduced to a total of two per test chamber to reduce competition for available spawning sites. No additional males were removed for the duration of the test.

During incubation, live eggs were counted and dead ones removed daily until hatching, on about the 4th day. Larvae were retained in the egg cups until the 7th day, when they were either counted and discarded or transferred to the set of 2-gal larval tanks for observation for 30 more days. Larvae were fed finely ground Oregon Moist "starter mash." The test was terminated after reproduction had slowed to less than one spawning a day among all the tanks for a week. As spawning rates at the various concentrations did not change near the end of the test, the spawning results presumably would not have been altered if the test had been allowed to continue.

Chemical Methods

Amperometric titration procedures (American Public Health Association 1965) were followed to determine the total, mono-, and di- chloramine residual concentrations in the test chambers. Sensitivity in detecting the end points was increased by connecting the microammeter from the titration detection cell unit to a Bausch and Lomb 500-μv, VOM 7 recorder. The minimum detection level was approximately 1 μg/liter total chloramine. Measured concentrations of tap-water chloramines diluted serially 5–20-fold with distilled water at the same temperature yielded 90–100% total and mono- forms and 80% di- chloramine. Measured chloramine in tap water diluted with untreated lake water at the same temperatures showed 80-90% total and monochloramine and 40–100% dichloramine. This indicates the increased chlorine demand of untreated lake water over distilled water and the method's sensitivity within this dilution range.

All residual chloramine test concentrations were measured from grab samples. Total chloramines were measured 3 and 4 days a week in the 5-gal test tanks during the fathead minnow and amphipod studies, respectively, and twice a week in the 2-gal fathead fry chambers. Differential chloramines (mono- and di- forms) were measured approximately once each week in the 5-gal tanks and twice monthly in the 2-gal tanks. Monochloramines made up most of the total chloramine residual in the higher concentrations but only about 50%

TABLE 1. Total chloramine concentrations (μg/liter) measured in test chambers during amphipod and fathead minnow exposures.

Pair of test chambers	Amphipod tanks (5-gal)			Fathead minnows					
				5-gal tanks (adults)			2½-gal tanks (progeny)		
	N	Mean	Range	N	Mean	Range	N	Mean	Range
1	44	163.2±17.9[a]	123–227	3	154.0	123–168	21	212.5±25.5	168–276
2	41	68.5±12.7	34–89	56	84.8±13.8	47–123	22	108.0±23.3	63–148
3	42	34.7±7.5	20–47	55	42.8±7.9	26–72	28	40.4±10.1	26–67
4	40	16.3±6.4	6–43	55	16.5±4.6	3–27	27	16.8±6.4	7–35
5	41	3.4[b]	–	54	6.6[c]	<1–13	23	3.8±2.2	1–7
6	27	0	–	20	0	–	10	0	–

[a]One standard deviation of mean.
[b]Four times <1 μg/liter (recorded as nonmeasurable).
[c]Twice <1 μg/liter (recorded as nonmeasurable).

of the total in the two lowest concentrations. In terms of toxicity, no significance is attached to this difference in the percentages of mono- and di- chloramines. Since the amounts obtained by adding the measured values of mono- and di- chloramines did not always equal the measured total concentrations, small quantities of other forms of chloramines were probably present in the test tanks. Therefore, toxicity results and no-effect concentrations are expressed only in terms of total chloramines. During the amphipod study all grab samples for chloramine analysis (Table 1) were routinely taken from the tank's standpipe discharge. Analyses of water from the middle and bottom of the test tanks revealed about 25% higher total chloramine concentrations at these depths than in the standpipe discharge. In the fish studies, all chloramine grab samples (Table 1) were taken at midtank depths.

Routine water-chemistry determinations were conducted once a week during the long-term studies. Dissolved oxygen, *p*H, total hardness, alkalinity, and acidity were measured by standard methods given by the American Public Health Association (1965). The ranges of these measurements in the test chamber waters during the studies were, respectively, 5.2–10.4, 7.2–8.6, 44–48, 42–48, and 0.7–4.4 mg/liter.

Results

Adult survival of amphipods during the 15-week study was markedly less at ≥35 μg/liter measured total residual chloramines than in the untreated water controls (Table 2). No young were produced in the tanks containing ≥35 μg/liter total chloramines. Total numbers of young produced per adult female at the end of the tests were markedly less in concentrations of 3.4 and 16 μg/liter than in the controls.

The total chloramine 96-hr TL_m value for amphipods was 220 μg/liter (205 and 235 in replicate determinations). All 20 fathead minnows in the tanks containing 154 μg/liter total chloramines were killed within 72 hr. In the next highest concentration (85 μg/liter), the first died after 7 days (Table 3). Therefore, the 96-hr TL_m for fathead minnows was between 85 and 154 μg/liter total chloramines.

On April 2, 1970, the city of Duluth started fluoridating the potable water supply to approximately 1.0 mg fluoride/liter, added as H_2SiF_6. No differences were detected in fathead minnow spawning or survival of larvae from this date to the end of the study. On the basis of the amount of tap water mixed with untreated lake water from the diluter, the calculated concentrations of fluoride in the tanks with 16 and 43 μg/liter total chloramine were approximately 77 and 126 μg/liter, respectively. The 96-hr TL_m of fathead minnows to fluoride (D. T. Olson personal communication) has been shown to be approximately 75 mg/liter, so the amount present during this study is not thought to have influenced the results.

No significant differences ($P = 0.05$)[1] in growth or survival of adult fathead minnows were found at concentrations ≤43 μg/liter total chloramine (Table 3). Although two mortalities occurred at 43 μg/liter that could not be attributed to disease, neither were they thought to have been caused by chloramines. In some of the test tanks, one or more of the males never attained full development. This condition could have resulted from an inhibitory effect exerted by more aggressive fish guarding available spawning sites and not from toxicant effects, since

[1]Dunnett's test for comparing treatment means with control means.

its greatest occurrence was in tank 16B, an intermediate concentration containing the largest number of males.

Spawning was practically eliminated at a concentration of 85 µg/liter total chloramine (Table 4). The number of spawnings per female was significantly reduced ($P = 0.05$) at 43 µg/liter, and fewer eggs per female were produced at this concentration than in the lower test concentrations and control. Among groups of eggs incubated, no toxicant-induced differences were observed in the percentage of larvae surviving after 7 days (Table 4). Growth and survival of fathead minnow larvae for the next 30 days (Table 5) were reduced only at 108 µg/liter.

Discussion

This study showed that the lowest total residual chloramine concentrations having no effect on the amphipod and fathead minnows were <3.4 and 16 µg/liter, respectively. The effect of the lowest toxic concentrations was a reduction in the number of offspring produced.

TABLE 2. Survival and reproduction of amphipods in duplicate tanks during 15 weeks' exposure to various chloramine concentrations.

Mean measured total chloramine (*µg/liter*)	Tank	Alive at end of test (males/females)[a]	Final gravid females	Young per female
163	A	0[b]	0	–
	B	1[b]	0	–
69	A	9[b]	0	–
	B	5[b]	0	–
35	A	2/0	0	–
	B	3/0	0	–
16	A	4/6	0	2.2
	B	9/7	0	4.1
3.4	A	4/4	2	2.2
	B	7/3	0	–
0	A	8/5	1	27.8
	B	7/7	4	21.0

[a]Initial number of amphipods per tank 25.
[b]Sex could not be determined.

TABLE 3. Survival and growth of adult fathead minnows in duplicate tanks after 21 weeks' exposure to various chloramine concentrations.

Mean measured total chloramine (*µg/liter*)	Tank	Final no. surviving (males/females)[a]	Final mean adult wt (*g*)[b]	
			Males	Females
154	A	0	–	–
	B	0	–	–
85	A	3/0	2.42	–
	B	4/3	2.27	1.20
43	A	5/5	2.14	0.95
	B	3/5	2.18	1.33
16	A	3/7	3.08	1.36
	B	7/2	2.58	1.23
6.6	A	5/4	2.27	1.05
	B	4/5	2.74	1.20
0	A	2/5	3.33	1.36
	B	2/5	3.05	2.07

[a]Initial number of fish per tank 10.
[b]Initial weights (mean and range) of a random sample of 14 starting size fish were 0.46 and 0.38–0.58 g.

TABLE 4. Spawning activity of fathead minnow adults and survival of larvae in duplicate tanks after 7 days' exposure to various chloramine concentrations.

Mean measured total chloramine (*µg/liter*)	Tank	Total spawnings	Spawnings/female	Eggs/spawning	Eggs/female	Eggs (and no. groups) incubated	Mean % survival at 7 days
85	A	0	0	0	0	25(1)[a]	96
	B	1	0.3	18	6	100(4)[a]	78
43	A	13	2.6	94	245	425(9)	24
	B	16	3.2	67	214	375(8)	79
16	A	37	5.3	109	578	1000(20)	69
	B	8	4.0	129	517	225(5)	37
6.6	A	32	6.4	77	613	375(8)	77
	B	24	4.8	86	411	450(10)	80
0	A	25	5.0	77	383	300(8)	75
	B	35	7.0	140	982	500(12)	88

[a]Egg batches for 85A and 85B came from control tanks.

TABLE 5. Survival and growth of fathead minnow larvae in duplicate tanks after 30 days' exposure to various chloramine concentrations.

Mean measured total chloramine (*μg/liter*)	Tank	Initial no. of larvae	% survival	Final mean wt (*g*)[a]
108	A	24	38	0.014[b]
	B	–	–	–
40	A	37	68	0.032
	B	25	80	0.036
17	A	34	76	0.044
	B	–	–	–
3.8	A	44	98	0.074
	B	49	100	0.069
0	A	43, 49	72, 71	0.038, 0.041
	B	43	93	0.047

[a]Initial weights were similar for all concentrations and averaged 0.0008 g among a random sample of 10 larvae.

[b]Larvae from the egg batch in adult tank 85A (Table 4).

Little information is available about chlorine toxicity to invertebrates, but preliminary work at this laboratory with *Daphnia magna* (K. E. Beisinger personal communication) indicates that chloramines kill all individuals exposed to a concentration of approximately 1 μg/liter in 3–5 days. This result was obtained from two successive experiments with five animals in each duplicate test container and with the same experimental apparatus as described herein.

Other investigations of toxicity of residual chlorine to fish have also demonstrated effects at low levels. J. A. Zillich (personal communication), also using fathead minnows, conducted continuous-flow bioassays in chlorinated sewage effluents at several sewage-treatment plants in Michigan. He found 4-day partial kill concentrations within the range of 50–190 μg/liter total residual chlorine in effluents containing no industrial wastes, which agrees closely with the acutely toxic levels in tap water in the present study. Similarly, Merkens (1958) killed "about half a batch of rainbow trout in 7 days" at a residual chlorine concentration of 80 μg/liter, mostly in the form of monochloramine. He extrapolated to a concentration that possibly would be safe to half the fish in 1 year of 4 μg/liter, or 1/20th the 7-day median tolerance concentration.

The data reported in this study argue against such a relation, since the concentration lethal to all fish within 3 days was only twice the concentration lethal to 50% of the fish in 5 months. However, Sprague and Drury (1969) have demonstrated an avoidance response to free chlorine by rainbow trout at only 1 μg/liter.

Acknowledgments

The authors especially thank Mrs B. Halligan for performing all the residual chloramine analyses for this study. We express appreciation to Messrs R. Andrew and E. Leonard, research chemists, for increasing the sensitivity of the amperometric titrations, and to Miss V. Snarski for assistance in egg-handling procedures.

AMERICAN PUBLIC HEALTH ASSOCIATION. 1965. Standard methods for the examination of water and wastewater. 12th ed. APHA, New York, N.Y. 769 p.

HAMILTON, D. H., D. A. FLEMER, C. W. KEEFE, AND J. A. MIHURSKY. 1970. Power plants: effects of chlorination on estuarine primary production. Science 169: 197–198.

HOLLAND, G. A., J. E. LASATER, E. D. NEUMANN, AND W. E. ELDRIDGE. 1960. Toxic effects of organic and inorganic pollutants on young salmon and trout. Wash. Dep. Fish. Res. Bull. 5: 203–215.

MERKENS, J. C. 1958. Studies on the toxicity of chlorine and chloramines to the rainbow trout. J. Water Waste Treat. 7: 150–151.

MOUNT, D. I. 1968. Chronic toxicity of copper to fathead minnows (*Pimephales promelas*, Rafinesque). Water Res. 2: 215–223.

MOUNT, D. I., AND W. A. BRUNGS. 1967. A simplified dosing apparatus for fish toxicology studies. Water Res. 1: 21–29.

SPRAGUE, J. B., AND D. E. DRURY. 1969. Avoidance reactions of salmonid fish to representative pollutants, p. 169–179. *In* S. H. Jenkins [ed.] Advances in water pollution research. Proc. 4th Int. Conf., Prague, Pergamon Press, New York and Oxford.

TSAI, C. 1970. Changes in fish populations and migration in relation to increased sewage pollution in Little Patuxent River, Maryland. Chesapeake Sci. 11: 34–41.

Predation by Rainbow Trout (*Salmo gairdneri*): the Effect of Experience[1]

D. M. WARE[2]

Institute of Resource Ecology
The University of British Columbia, Vancouver, B.C.

WARE, D. M. 1971. Predation by rainbow trout(*Salmo gairdneri*): the effect of experience. J. Fish. Res. Bd. Canada 28: 1847–1852.

Rainbow trout (*Salmo gairdneri*) provided with unfamiliar palatable food changed several components of their feeding behaviour and demonstrated that they can develop searching images for specific prey. Naive fish required an average of 4 days of experience, each of which consisted of exposure to six food particles, before they approached novel prey. After this time the distance from which trout attacked food improved and had doubled by the 12th day of exposure. When conditioned animals were deprived of experience for 90 days, the distance of reaction fell back to the initial naive level. The relation of these results to current work on searching image formation is discussed.

WARE, D. M. 1971. Predation by rainbow trout (*Salmo gairdneri*): the effect of experience. J. Fish. Res. Bd. Canada 28: 1847–1852.

Des truites arc-en-ciel (*Salmo gairdneri*) mises en présence d'aliments sapides étrangers modifient plusieurs aspects de leur comportement alimentaire et démontrent leur capacité de former une image des proies particulières qu'elles recherchent. Une expérience de 4 jours, comportant chacun une exposition à six particules de nourriture, est requise en moyenne pour qu'un poisson non initié s'approche d'une proie étrangère. Par la suite, la distance à laquelle les truites se lancent à l'attaque de la nourriture augmente graduellement, pour doubler après 12 jours d'expérience. Lorsque des truites conditionnées ont été privées d'expérience pendant 90 jours, leur comportement alimentaire redevient celui de poissons noninitiés. Nous analysons ces résultats à la lumière d'une étude en cours sur la formation d'images dans la recherche des proies.

Received May 19, 1971

THERE is empirical support for the "searching image" concept proposed by Tinbergen (1960), because experiments with a variety of vertebrate predators have shown that foraging behaviour is modified by experience with prey (de Ruiter 1952; Beukema 1968; Holling 1959; Croze 1970). Holling (1965) analysed the influence of associative learning on the functional response of predators to prey by incorporating a subsidiary process, in which a predator's reaction to food was regulated by feedback between hunger and prey palatability, into a general model of feeding behaviour. Predator experience with different food organisms influenced the behaviour of the model, and was sufficient to simulate the classical characteristic of searching image formation: a sigmoid relation between the intensity of predation and prey density.

Since there is little documented work on the effect of experience on predation by fish, the present study was undertaken to determine if exposure to unfamiliar food altered the feeding response of rainbow trout (*Salmo gairdneri* Richardson). Results presented support the hypothesis that the distance of reaction improves with experience as Holling postulated, and that trout display the characteristics necessary to form searching images.

Methods and Materials

Rainbow trout ranging in length from 11 to 14 cm (1–2 years old) were obtained from Marion Lake, British Columbia. To ensure complete unfamiliarity with the experimental food, they were exposed to artificial prey fabricated from commercial chicken liver. Previous work (unpublished data) established that this was palatable. The size, shape, and color of prey were standardized by blanching cylindrical pieces of liver, 3 mm diam

[1]Canadian Contribution to the International Biological Programme No. CCIBP 114.

[2]Present address: Fisheries Research Board of Canada, Marine Ecology Laboratory, Bedford Institute, Dartmouth, N.S.

Printed in Canada (J2171)

× 5 mm long, in water for about 10 min until they were white.

In preliminary trials (A) individual fish were placed in a small holding chamber suspended in a 227-liter (90 × 45 × 45-cm) glass aquarium. Before the predator was released, six standard prey were scattered around the tank. An experiment lasted 20 min and was considered to represent 1 "day" of experience whether the animal fed or not. Successive trials were conducted every 48 hr until the time required by the fish to ingest the food had stabilized. Predators were held in isolation and deprived of food between test periods.

Additional experiments (B) were carried out in a rectangular aquarium (180 × 16 × 30 cm) that had a small holding area at one end. This enclosure was visually separated from the remainder of the tank by an opaque sliding partition. For feeding, a predator was transferred to this chamber and allowed to quieten while a single food particle was placed approximately 100 cm away from the fish. When the predator was released, the distance from which it initiated an approach or rapid acceleration toward food (reactive distance) was estimated in relation to a centimeter scale fastened to one side of the tank. If the fish failed to attack after 30 sec it was returned to the enclosure then released again. In this event, the exposure was recorded as a response failure. When food was consumed, this same procedure was followed, the exception being that the position of successive food particles was varied between 150 and 100 cm from the holding chamber. In both instances, prey were well outside the reactive field of trout when they entered the tank. A single day of experience consisted of exposure to six prey, and at the end of a test period the fish were returned to separate holding tanks and deprived of food for 48 hr.

In one experiment, predators were exposed to food that had a lower contrast than standard prey. The level of target contrast was reduced by staining blanched food in a saturated solution of Sudan Black B. Several colors ranging from light grey to black could be reproduced by varying staining time. Since contrast is commonly defined as the difference in the amount of light reflected by a target with respect to the background (Le Grand 1967), the term is used in a relative sense throughout this paper. In both sets of experiments, white prey had a high contrast relative to other food because the floor of the experimental tanks were black.

Water temperature (10 ± 2 C), background illumination (0.3 ft-c) and turbidity of the water (attenuation coefficient, 0.50) were carefully controlled to ensure that the visual acuity or performance of the fish were not influenced by changes in these conditions.

Results and Interpretation

Experiment A: Development of the Feeding Response

The completion of a feeding sequence by experienced trout consisted of four distinct steps: positioning, approach, seizure, and ingestion. When trained animals were released they moved immediately to the bottom of the tank and searched until they located food. Before prey were approached, trout paused momentarily to fix the prey in the binocular field of vision. This was followed by a direct approach toward the prey, which was then seized and ingested.

Inexperienced fish exposed to white prey required several days of experience before they carried this sequence of steps to completion. Most animals did not acknowledge the presence of food and did not approach it until the 4th day of exposure (latent period). In a group of nine fish, this delay in response ranged from 1 to 11 days. Moreover, when feeding began some predators failed to seize or ingest some food particles. In general, 2 additional days of training were required to complete the development of the feeding response. By an average of 6 days, the fish consumed all food offered, in about 6 min. However, conditioning was still incomplete as the time devoted to feeding diminished with further exposure and finally stabilized around 30 sec on the 11th day of training (Fig. 1). Although there was no apparent increase in searching velocity during this phase, experienced fish required less time to complete a feeding response, largely because the time lag between positioning and approach was shortened. In addition to this effect, I felt that the rate of predation could have been accelerated by an improvement in the distance of reaction. Experiments were designed to test this possibility.

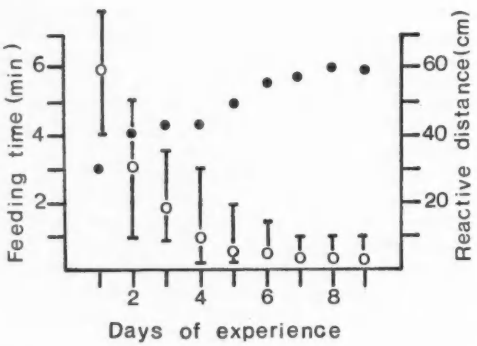

Fig. 1. Effects of experience on feeding time and reactive distance of two groups of trout after the latent phase. Open circles illustrate the range and average time nine fish (group A) required to capture six white prey. Solid circles indicate the change in average reactive distance of six different trout (B) to the same food (see Fig. 2).

Experiment B: Experience and Distance of Reaction

The distance from which six new and inexperienced fish attacked white food was recorded for several consecutive days after they completed the latent phase (Fig. 2). In every instance this response improved for about 6 days of training before it stabilized at approximately twice the naive level. Except for one animal (4) that required 10 days to develop a conditioned response, the rate of learning appeared reasonably consistent between individuals. If these data are pooled and compared with the first series of experiments (Fig. 1), it can be seen that the reactive distance of group B and the rate of predation of group A increased during the same training interval. Part of the explanation for the latter observation may be attributed to an improvement in reactive distance, for this would accelerate predation and diminish feeding time.

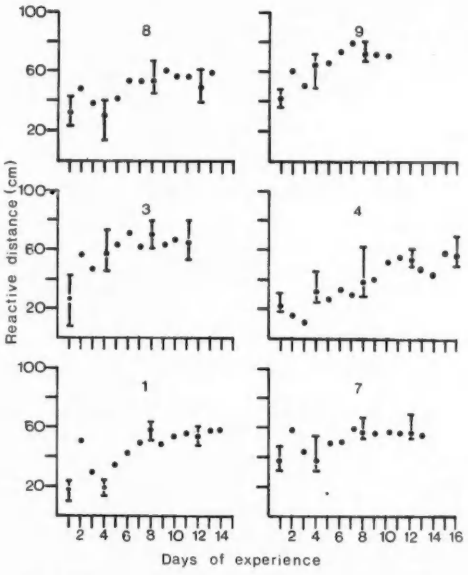

Fig. 2. Change in average reactive distance of six trout (group B) to white prey. The mean and range in observations for each fish is shown for several days of experience.

In the process of learning, the first few encounters with a palatable food are likely to have the greatest effect on the response of a predator. This hypothesis can be expressed as:

$$\frac{d\,RD}{d\,E} = a\,(RD_{max} - RD),$$

which integrates to

$$RD = RD_{max}\,(1 - e^{-a(E)+b}). \qquad (1)$$

In this instance, RD is the average distance of reaction for a specified level of experience (E), a and b are constants, and RD_{max} represents the distance from which a conditioned animal will attack. To test if this hypothesis was adequate to describe the elevation of reactive distance illustrated in Fig. 2, equation 1 was transformed to conform to a straight line, so that the coefficient of correlation, as well as the values of a (slope) and b (intercept) could be calculated by standard regression techniques. For analysis, the average distance (RD_{max}) was estimated by pooling all the data for the last test period. Table 1 clearly shows that a logarithmic transformation of the data was sufficient to describe the change in reactive distance with exper-

Table 1. Relation between average naive (RDT) and conditioned reactive distance (RD_{max}) of trout exposed to different colored prey. N indicates the number of experiments, followed by (in parentheses) the number of fish. K is the ratio between conditioned and initial distances of reaction. Values for constants a and b, and coefficient of correlation r were obtained by fitting the data to equation 1.

Prey	N	RDT (*cm*)	RD_{max} (*cm*)	*a*	*b*	*r*	K	Source
			Initial conditioning experiments					
White	30(6)	30	61	.23	.39	.57[a]	2.1	Fig. 2
Black	13(4)	18	40	.29	.33	.62[a]	2.2	Fig. 3D
			Reconditioning experiments					
Black	20(4)	17	32	.23	.65	.83[a]	1.9	Fig. 4

[a]Significant at or less than 0.01 level.

ience ($r = .57$), and verifies that equation 1 provides a satisfactory description of this learning process.

The experiments outlined above demonstrate that several components of feeding behaviour change after repeated exposure to palatable food. What they fail to show, however, is if any improvement in response is specific to a singular class of food objects, or is transferred to any target in the environment. To demonstrate searching image formation it must be shown that the response of trained fish is restricted to particular food organisms.

Transfer of learning

To examine whether the reactive distance of experienced animals was associated with the property of food contrast, nine trout were conditioned to white prey until the distance of reaction remained constant for 4 successive days. They were then switched at random to either light grey, dark grey, or black food. Two fish were assigned to each prey, the exception being that four fish were exposed to black food. The remaining animal served as a control.

It was not surprising that the maximum distance of reaction observed in each group appeared to be inversely related to food color (Fig. 3), because the positive relation between visual acuity and target contrast is well documented (Hester 1968). The significant point of these experiments is that the fish exposed to light and dark grey food reacted immediately, and that the initial distance of reaction did not improve significantly with additional experience.

On the other hand, there were two distinct changes in the behaviour of the trout switched to black prey. Their initial response was almost identical to inexperienced fish in the sense that they had to be released an average of 20 times before they approached the "new" food. After this delay, there was a substantial improvement in the distance of reaction. Figure 3D indicates that it doubled after 6 days of exposure and that this change in performance can be described by equation 1 (Table 1). Since this group of animals did not respond immediately nor from a maximum distance, these experiments support the hypothesis that the feeding response of experienced predators is somewhat specific to the type of food to which they have been trained. Trout may require several days of experience to transfer a learned association to prey that do not resemble familiar food.

Extinction and redevelopment of reactive distance

Usually a conditioned response will diminish in strength if reinforcement is removed. To determine the effect of long-term deprivation of experience on the reactive distance of trained fish, the four animals previously conditioned to black food were withheld from further exposure for 90 days. During this time they were fed white prey. Upon reexposure to black food (Fig. 4), the average distance of reaction (17 cm) was found to be identical to the group's naive performance (18 cm; Fig. 3D). Moreover, the time required to redevelop a maximum response was similar to the initial training period (Table 1).

The influence of shorter periods of deprivation on reactive distance was examined only in one experiment, and indicated that trout can maintain a conditioned response for at least 14 days without reinforcement. Therefore, after the removal of experience the distance of reaction begins to fall to the naive level some time after 2 weeks and is complete by 3 months.

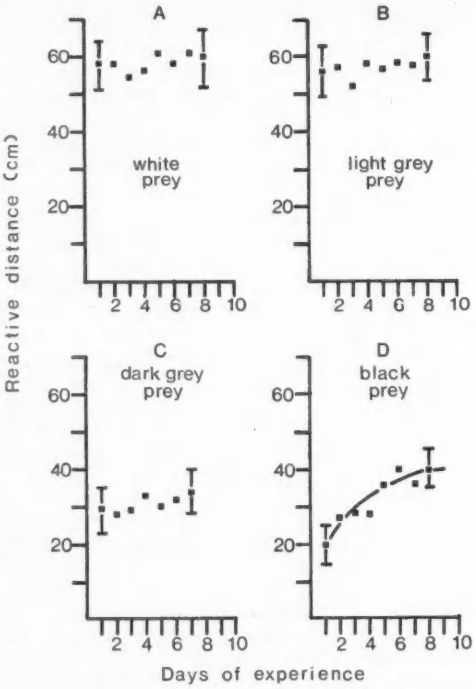

FIG. 3. Effects of switching trout conditioned to white food to prey with lower contrast. The 95% confidence limits of the mean are shown for the first and last days of experience. The curve in Fig. 3D was fitted to equation 1 (see Table 1).

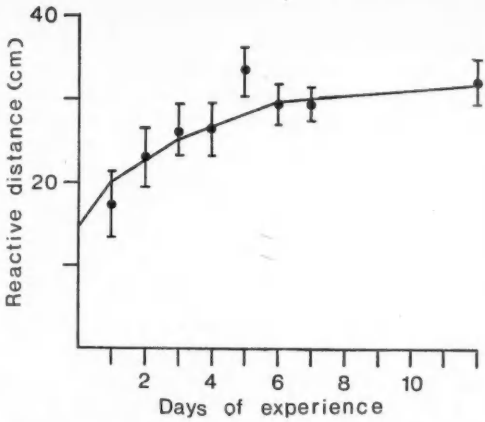

FIG. 4. Retraining of four trout to black prey after 90 days deprivation of experience. Average distances of reaction and 95% confidence intervals are indicated. The curve was obtained by fitting the data to equation 1 (see Table 1).

Discussion

It has been shown that exposure to unfamiliar but palatable food altered several components of the feeding behaviour of rainbow trout: the time delay between the acknowledgement of food and approach, the development of a complete feeding sequence, and the distance of reaction. Beukema (1968) reported that similar behavioural alterations occurred when sticklebacks were exposed to novel prey, and he concluded that these changes were necessary to explain searching image formation.

After an extensive study of a similar problem, Croze (1970) found that avian predators tended to attack only objects that had proven, through experience, to be reinforcing. The present study confirms that the process of association is related to the physical properties of the food and that vertebrate predators do not exhibit complete generalization. If these studies are taken into consideration, then searching image formation may be operationally defined in its simplest state as a two-stage process of development: (1) an initial latent phase, followed by (2) an increase in the distance from which predators react to specific prey. A final and necessary condition is that the distance of reaction must decline to the naive level in the absence of reinforcement.

Holling (1965) proposed that hunger motivation was the underlying basis of this learning process, and suggested that exposure to palatable food operated to lower the level of hunger a predator had to pass before it would attack. As a result, his model predicted that the distance of reaction would improve with experience but diminish as the predator approached satiation (attack threshold). Although the first premise is sufficient to account for the nonlinear development in the reactive distance of inexperienced trout to artificial food, there is some question as to the generality of the second premise, and therefore, that a shift in hunger thresholds is the actual mechanism of searching-image formation. The evidence available at present strongly indicates that the reactive distance of trained sticklebacks (Beukema 1968) and trout (unpublished data) is not affected by food deprivation. If this pattern is confirmed for other vertebrates, then Holling's model must be modified to incorporate an alternate pathway in which experience directly alters the distance of reaction, rather than indirectly through hunger.

Irrespective of the actual basis of learning, trout can improve their response to prey if they obtain sufficient exposure. This conclusion may help to explain why salmonids tend to feed predominantly on one or two main food organisms and to a lesser extent on alternative prey (Allen 1941). Naturally, the diet of predators will be determined by the availability and distribution of food, but the potentially powerful effect of learning on predation cannot be overlooked, because variations in the experiences and motivational levels of predators will influence the rate at which they eliminate different foods. Future work on the relation of learning to feeding behaviour will undoubtedly reveal that development of the searching image is an extremely complex process but is a fundamental characteristic of vertebrate predation.

Acknowledgments

I would especially like to thank Dr I. Efford for his support and encouragement during this study. Drs C. Holling, R. Liley, V. Brawn, and S. Kerr offered valuable criticism of an earlier draft of the manuscript.

ALLEN, K. R. 1941. Studies on the biology of the early stages of the salmon (*Salmo salar*). J. Anim. Ecol. 10: 47–76.

BEUKEMA, J. J. 1968. Predation by the three-spined stickleback (*Gasterosteus aculeatus* L.): the influence of hunger and experience. Behaviour 31: 1–126.

CROZE, H. 1970. Searching image in carrion crows. Z. Tierpsychol. Suppl. 5: 86 p.

HESTER, F. J. 1968. Visual contrast thresholds of the goldfish (*Carassius auratus*). Vision Res. 8: 1315–1336.

HOLLING, C. S. 1959. The components of predation as revealed by a study of small-mammal predation of

the European pine sawfly. Can. Entomol. 91: 293–320.

1965. The functional response of predators to prey density and its role in mimicry and population regulation. Mem. Entomol. Soc. Can. 45: 1–60.

LE GRAND, Y. 1967. Form and space vision. Indiana Univ. Press, Bloomington, Ind. 367 p.

RUITER, L. DE. 1952. Some experiments on the camouflage of stick caterpillars. Behaviour 4: 222–232.

TINBERGEN, L. 1960. The natural control of insects in pinewoods. I. Factors influencing the intensity of predation by song birds. Arch. Neer. Zool. 13: 265–336.

Egg Proteins of Coho Salmon (*Oncorhynchus kisutch*): Chromatographic Separation and Molecular Weights of the Major Proteins in the High Density Fraction and their Presence in Salmon Plasma

J. R. MARKERT AND W. E. VANSTONE

Fisheries Research Board of Canada
Vancouver Laboratory, Vancouver 8, B.C.

MARKERT, J. R., AND W. E. VANSTONE. 1971. Egg proteins of coho salmon (*Oncorhynchus kisutch*): chromatographic separation and molecular weights of the major proteins in the high density fraction and their presence in salmon plasma. J. Fish. Res. Bd. Canada 28: 1853–1856.

The molecular weights of the three major proteins in the soluble fraction of coho salmon (*Oncorhynchus kisutch*) eggs were found to be: lipovitellin, 390,000; β'-component, 30,000; and phosvitin, 27,000. Immunological techniques showed that these proteins were present in the plasma of sexually maturing female coho and of estrogenized prepuberal coho of both sexes but not of sexually maturing males or nonestrogenized prepuberal coho. These findings support the previous postulation that the β'-component should be classified not as a livetin but as an egg protein, as are lipovitellin and phosvitin.

MARKERT, J. R., AND W. E. VANSTONE. 1971. Egg proteins of coho salmon (*Oncorhynchus kisutch*): chromatographic separation and molecular weights of the major proteins in the high density fraction and their presence in salmon plasma. J. Fish. Res. Bd. Canada 28: 1853–1856.

Le poids moléculaire des trois principales protéines de la fraction soluble de l'œuf de saumon coho (*Oncorhynchus kisutch*) a été établie comme suit: lipovitelline, 390,000; β'-composant, 30,000; et phosvitine, 27,000. Des techniques d'immunologie ont démontré la présence de ces protéines dans le plasma de saumons coho femelles en voie de maturation et dans celui de saumons impubères des deux sexes traités aux oestrogènes. Par contre, elles sont absentes des mâles en voie de maturation et des saumons impubères nonoestrogénés. Ces résultats confirment un postulat déjà émis, à l'effet que le β'-composant doit être considéré, non comme une livetine, mais comme une protéine ovulaire, au même titre que la lipovitelline et la phosvitine.

Received April 20, 1970

THE high density fraction (HDF) is a solution of soluble constituents and is one of three components resolved by centrifugation of the fluid from unfertilized teleost eggs (Markert and Vanstone 1968). This fraction has been shown to contain two major protein components similar to phosvitin and lipovitellin of hen's egg by ultracentrifugation (Ando 1964) and paper electrophoresis (Felix and Goppold-Krekels 1962), whereas starch grain electrophoresis (Ito et al. 1963), chromatography on TEAE-cellulose (Jared and Wallace 1968), and electrophoresis on cellulose acetate (Markert and Vanstone 1968) revealed three major protein zones, a lipoprotein, a phosphoprotein, and a protein that contained neither lipid nor phosphorus and that was called "simple" protein by Ito et al. (1963) and "β-component" by Jared and Wallace (1968).

Printed in Canada (J2142)

Wallace et al. (1966, 1968) found that extensive dilution of a saline extract of trout egg HDF precipitated the lipoprotein and the phosphoprotein leaving the β-component in solution. Since Williams (1962) had established that the water-soluble protein component (livitins) of hen's egg yolk are serum proteins, these investigators suggested that the three proteins represented lipovitellin, phosvitin, and a serum protein. Upon similar dilution of HDF from eggs of five other salmonids (*Oncorhynchus* spp.), the simple protein, hereinafter referred to as β′-component, coprecipitated with the lipoprotein and the phosvitin, which would be an unusual property if the β-component was in fact a serum protein (Markert and Vanstone 1968).

This is a report on the relation between the solubilities of lipovitellin, β′-component, and phosvitin; estimates of the molecular weights of these proteins; and their occurrence in the plasma of sexual-

ly maturing coho salmon (*Oncorhynchus kisutch*) and of estrogenized prepuberal coho salmon.

Materials and Methods

Sexually mature coho salmon were obtained from the Great Central Lake system, Vancouver Island, B.C., and the eggs removed. The eggs were washed, broken, and centrifuged as before (Markert and Vanstone 1968), without dilution of the egg contents. The HDF was drained off and either used immediately or stored at −5 C. No differences were observed between the results obtained using freshly prepared HDF and HDF that had been stored up to 3 months at −5 C. Livetins were removed from the HDF by three distilled water precipitations of the lipovitellin–β′-component–phosvitin complex (LSPC). The final precipitate of LSPC was dissolved in 0.5 M NaCl and the solution used for column chromatography and for the preparation of phosvitin-free coho LSPC (LSC) by ammonium sulphate precipitation (Wallace et al. 1966). The precipitate of LSC, which floated on the $(NH_4)_2SO_4$ solution of phosvitin, was washed three times with ice-cold 67% saturated ammonium sulphate and was finally taken into solution by the addition of enough distilled water to lower the $(NH_4)_2SO_4$ concentration. This solution of LSC was used for column chromatography. The solution of phosvitin was dialyzed against flowing distilled water for 10 days at 4 C, a trace of insoluble material was centrifuged off, and the supernatant was further dialyzed for 5 days, centrifuged, and then lyophilized. This method yielded a product with a N/P ratio of 3.31.

Sephadex G-200 was allowed to swell for 3 days in distilled water, packed as a slurry into a 2.5 × 100-cm column fitted for upward flow, and equilibrated with distilled water overnight. The column was then reequilibrated with 0.5 M NaCl for 1 day before being used for the fractionation of coho LSPC and LSC by elution with 0.5 M NaCl and collection of 3-ml fractions. Coho LSPC was prepared for chromatography and chromatographed on TEAE-cellulose according to the procedure of Jared and Wallace (1968). All chromatography was performed at 4 C.

Portions of each isolated protein component were rechromatographed and then analysed for total nitrogen by the micro-Kjeldahl method, total lipid (Folch et al. 1947), and total phosphorus and lipid phosphorus (King 1937), and were separated into four classes of phosphorus-containing compounds by the method of Schneider (1945), each of which were analysed for total phosphorus (King 1937). Molecular weights were estimated by gel filtration (Whitaker 1963; Andrews 1964, 1965) on Sephadex G-150, G-200, and Sepharose 6 B (Pharmacia (Canada) Ltd., Montreal, P.Q.). Non-enzymic molecular weight markers (Mann Research Laboratories, New York, N.Y., were used for calibration of the columns.

Immune serum against HDF and purified lipovitellin, β′-component, and phosvitin were prepared in rabbits by the method of Mok and Common (1964). Immunodiffusion was carried out in flat-bottom petri dishes containing 10 ml of 1% agar in veronal buffer 0.05 M, *p*H 8.6.

Blood from sexually maturing and sexually mature male and female coho salmon were taken from fish at Big Qualicum River on Vancouver Island and from male and female coho salmon reared in captivity at this laboratory, and the plasma samples used for immunidiffusion.

Male and female prepuberal laboratory-reared coho salmon, weighing 120 g, that had been in sea water for 6 months were injected interperitoneally twice weekly for 6 weeks with 0.5 ml 30% ethanol containing 1 mg 17β-estradiol. Prepuberal coho (controls) were similarly injected with 0.5 ml 30% ethanol. Three days after the last injection, blood samples were taken and the plasma used for immunodiffusion.

Results and Discussion

Chromatography on sephadex (Fig. 1) of LSPC yielded two components, which were designated as lipovitellin (L) and β′-component–phosvitin complex (β′–P). Similar chromatography of LSC also yielded two components, lipovitellin (L) and β′-component (β′). Material eluted in the positions indicated by the horizontal bars in Fig. 1 were rechromatographed on Sephadex as before, pooled, and used for further analysis and as a source of antigens.

Rechromatography of coho lipovitellin on hydroxyapatite using a gradient phosphate buffer of *p*H 8.6 (Bernardi and Cook 1960) yielded only one peak, as reported previously (Markert and Vanstone 1968). Lipovitellin, on a dry weight basis after correcting for salt content, contained 12.5% nitrogen, 24.3% lipid, and 0.56% total phosphorus (Table 1). When subjected to the fractionation procedure of Schneider (1945), all phosphorus was found to be in the lipid fraction. The molecular weight as estimated on Sepharose 6B was 390,000.

Although the molecular weight of 390,000 is very similar to that of amphibia lipovitellin, 420,000 (Wallace 1963), and bird lipovitellin, 400,000 (Barnardi and Cook 1960), it is much larger than the 240,000–260,000 reported for another salmonid (Ando 1964). Since the molecular weight markers used were not lipoprotein, our value of 390,000 for the molecular weight of lipovitellin is suspect, and a value of 250,000 may be more realistic. Protein nitrogen, after correcting for lipid content and phospholipid nitrogen ($0.56 \times 14/31 = 0.25$), was 16.2%, which compares favorably with values of 17.15 for bird (Barnardi and Cook 1960) and 15.1 for rainbow trout (*Salmo gairdneri*) vitellins (Jared and Wallace 1968). The value of 24.3% total lipid was in close agreement with the value of 25% reported for rainbow trout (Jared and Wallace 1968); however, we found that all lipovitellin phosphorus was

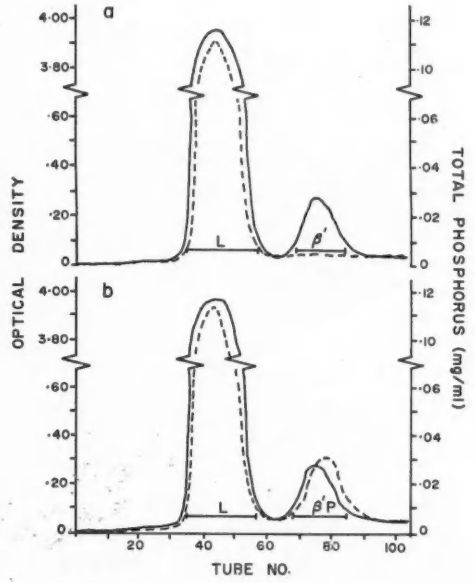

FIG. 1. Chromatography of (*a*) lipovitellin–β′-component complex and (*b*) lipovitellin– β′-component–phosvitin complex on Sephadex G-200 eluted with 0.5 M NaCl. Solid line indicates the optical density of the effluent at 280 mμ; broken line the total phosphorus in mg/ml. Horizontal lines indicate the fractions pooled for further analysis.

TABLE 1. Composition of coho salmon egg lipovitellin, β′, and phosvitin. Values are expressed as percent of protein component on a dry weight basis, except as otherwise indicated.

	Lipovitellin	β′	Phosvitin
Total nitrogen	12.5	14.7	12.5
Protein N (as % of vitellin)	16.2	–	–
Total lipid	24.3	0	0
Lipid phosphorus	0.56	–	–
Acid-soluble phosphorus	0	0	8.33
Other phosphorus fractions	0	0	0
N/P ratio	–	–	3.32
Molecular weight	390000	30000	27000

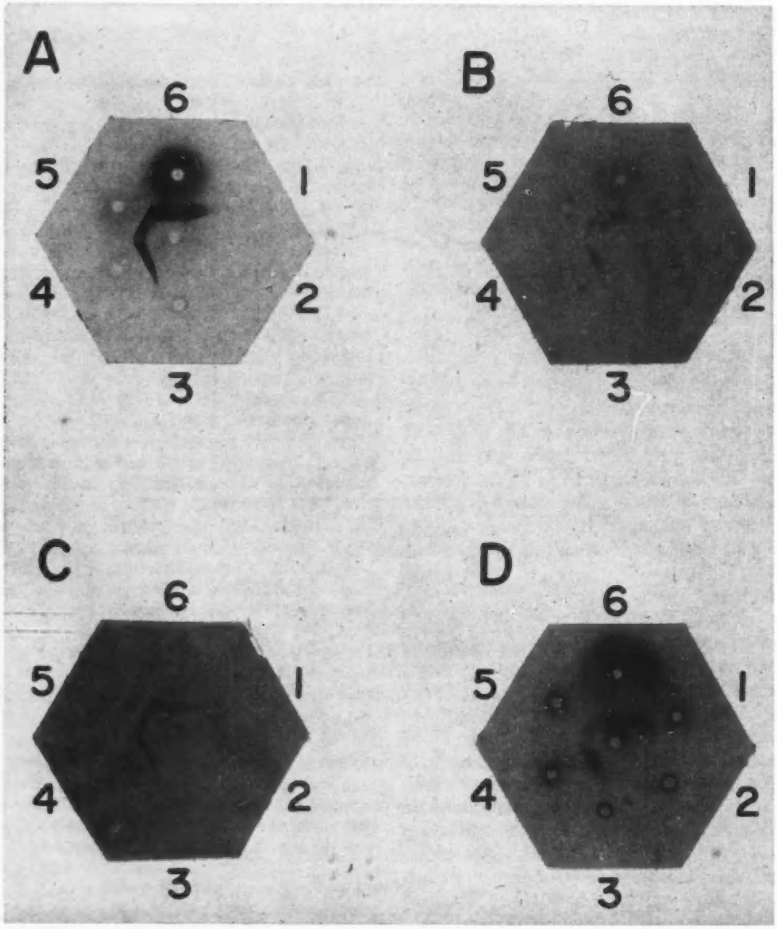

FIG. 2. Immunodiffusion of coho salmon plasma against: (A) anti-HDF serum; (B) anti-lipovitellin serum; (C) anti-β'-component serum; and (D) anti-phosvitin serum in agar gel, veronal buffer 0.05 M, *p*H 8.6, stained with amidoschwarz 10B. The antiserum was applied in the center as well. The outer wells in each photograph contained coho plasma from: (1) sexually maturing wild adult male; (2) sexually maturing laboratory-reared adult male; (3) nonestrogenized prepuberal coho; (4) sexually maturing wild adult female; (5) sexually maturing laboratory-reared adult female; (6) estrogenized prepuberal coho.

present as lipid phosphorus, whereas the trout lipovitellin contained 0.07% protein phosphorus (Jared and Wallace 1968). As noted previously, the yolk proteins of most teleosts are much less phosphorylated than are those of other egg-laying vertebrates (Jared and Wallace 1968), but our inability to detect any protein phosphorus in coho lipovitellin was unexpected.

Dialysis of the β′-component–phosvitin complex followed by lyophilization yielded a water-soluble powder that did not contain lipid. All phosphorus was present in the acid-soluble fraction that would arise from the acid solubility of teleost phosvitin (Wallace et al. 1966; Schmidt et al. 1965; Ito et al. 1966). Dialysis of the β′-component resulted in its precipitation, which was collected by centrifugation and washed three times with distilled water. The β′-component was soluble in 0.5 M NaCl, had an estimated molecular weight of 30,000 on Sephadex G-200, and contained 14.7% nitrogen but no lipid or phosphorus.

Dialysis of the phosvitin component followed by lyophilization yielded a water- and acid-soluble white material with a molecular weight of 27,000 estimated on Sephadex G-150. This material contained 12.5% nitrogen, 8.33% phosphorus, and no lipid, and had an N/P ratio of 3.31. The molecular weight of 27,000 is higher than those reported for other salmonids: rainbow trout, 24,000 (Wallace et al. 1966), 19,350 (Mano and Yoshida 1969); brown trout (*S. trutta*), 18,500 (Schmidt et al. 1965); and chum salmon (*O. keta*), 19,000 (Mano and Yoshida 1969). The N/P ratio of 3.31 is the same as the value of 3.3 reported for brown trout (Schmidt et al. 1965) but higher than the values of 2.79 and 3.0 reported for rainbow trout (Wallace et al. 1966; Ito et al. 1966).

Jared and Wallace (1968) have separated rainbow trout egg-yolk proteins into three components, α-, β- γ-, by chromatography on TEAE-cellulose. These investigators showed that the α- and γ-components corresponded to lipovitellin and phosvitin, respectively. Extensive dilution of the saline extract of rainbow trout eggs resulted in the coprecipitation of α- and γ-components, leaving their β-component in solution, and they proposed that this component be classed as a livetin. We obtained similar elution patterns of α-, β-, and γ-components after chromatography of TEAE-cellulose of LSPC from coho salmon eggs, but were unable to separate the β′-component from the α- and γ-components by dilution methods alone.

To examine further the solubility relations of coho β′-component and phosvitin, phosvitin was added to a saline solution of β′-component. Following dialysis, which did not produce a precipitate, and lyophilization, the recombined material was water-soluble. This altered solubility of β′-component is reminiscent of the altered solubility of avian lipoprotein, apparently because of the presence or absence of phosvitin (Wallace 1965). Ammonium sulphate precipitation of an aqueous solution of the β′-component–phosvitin component, or of recombined β′-component–phosvitin, yielded a precipitate of β′-component and a solution of phosvitin that upon purification were identical to the β-component and phosvitin prepared from LSC and LSPC directly.

Immunodiffusion of plasma from sexually maturing female coho and from estrogenized prepuberal coho of either sex against rabbit antisera showed that plasma from these fish contained HDF, lipovitellin, β′-component, and phosvitin (Fig. 2), whereas plasma from maturing males and from nonestrogenized prepuberal coho of either sex did not. Since no precipitation lines were detected in the latter against HDF, these results confirm previous findings that coho eggs contain only trace amounts of livetins. No lipovitellin or β′-component was detectable in the plasma from spawning female coho; however, traces of phosvitin were detectable in some, but not all, of the plasma samples from these fish. It is suggested that production of these yolk proteins ceases as the eggs become fully developed. These immunological results show that the β′-component is not a livetin and is in fact a unique egg protein as previously postulated.

Acknowledgments

We thank Dr R. A. Wallace, Oak Ridge National Laboratory, Oak Ridge, Tennessee, for his critical review of this work.

ANDO, K. 1964. Ultracentrifugal analysis of yolk proteins in rainbow trout egg and their changes during development. Can. J. Biochem. 43: 373–379.

ANDREWS, P. 1964. Estimation of the molecular weights of proteins by sephadex gel–filtration. Biochem. J. 91: 222–233.

1965. The gel–filtration behaviour of proteins related to their molecular weights over a wide range. Biochem. J. 96: 595–606.

BERNARDI, G., AND W. H. COOK. 1960. Separation and characterization of the two high density lipoproteins of egg yolk, α- and β-lipovitellin. Biochim. Biophys. Acta 44: 96–105.

FELIX, K., AND A. GOPPOLD-KREKELS. 1962. Über die Eiweisstoffe der forelleneier. Hoppe-Seyler's Z. Physiol. Chem. 328: 212–217.

FOLCH, J., M. LEES, AND G. H. SLOANS STANILEY. 1947. A simple method for the isolation and purification of total lipids from animal tissue. J. Biol. Chem. 226: 497–509.

ITO, Y., T. FUJII, M. KANAMORI, T. HATTORI, AND R. YOSHIOKA. 1966. Phosvitin of the trout roe. J. Biochem. 60: 726–728.

ITO, Y., T. FUJII, AND R. YOSHIOKA. 1963. On a phosvitin isolated from trout egg. J. Biochem. 53: 242–243.

JARED, D. W., AND R. A. WALLACE. 1968. Comparative chromatography of the yolk proteins of teleosts. Comp. Biochem. Physiol. 24: 437–443.

KING, E. J. 1937. The colorimetric determination of phosphorus. Biochem. J. 26: 292–297.

MANO, Y., AND M. YOSHIDA. 1969. A novel composition of phosvitins from salmon and trout roe. J. Biochem. 66: 105–108.

MARKERT, J. R., AND W. E. VANSTONE. 1968. Egg proteins of Pacific salmon, genus (*Oncorhynchus*): proteins in the soluble fraction. Can. J. Biochem. 46: 1334–1337.

MOK, C-C., AND R. H. COMMON. 1964a. Antigenicity of phosvitin. Poult. Sci. 43: 549–553.

1964b. Studies on the livetins of hen's egg yolk. I. Identification of paper–electrophoretic livetin fractions with serum protein antigens by immunoelectrophoretic analysis. Can. J. Biochem. 42: 871–881.

1964c. Studies on the livetins of hen's egg yolk. II. Immunoelectrophoretic identification of livetins with serum proteins. Can. J. Biochem. 42: 1119–1131.

SCHMIDT, G., G. BARTSCH, T. KITAGAWA, K. FUJISAWA, J. K. NOLLE, J. JOSEPH, P. DE MARCO, M. LISS, AND R. HASCHEMEYER. 1965. Isolation of a phosphoprotein of high phosphorus content from the eggs of brown trout. Biochem. Biophys. Res. Commun. 18: 60–65.

SCHNEIDER, W. C. 1945. Phosphorus compounds in animal tissues. I. Extraction and estimation of desoxypentose nucleic acid and of pentose nucleic acid. J. Biol. Chem. 161: 293–303.

WALLACE, R. A. 1963. Studies on amphibian yolk. IV. An analysis of the main-body component of yolk platelets. Biochim. Biophys. Acta 74: 505–518.

1965. Resolution and isolation of avian and amphibian yolk-granule proteins using TEAE-cellulose. Anal. Biochem. 11: 297–311.

WALLACE, R. A., D. W. JARED, AND A. Z. EISEN. 1966. A general method for the isolation and purification of phosvitin from vertebrate eggs. Can. J. Biochem. 44: 1647–1655.

WHITAKER, J. R. 1963. Determination of molecular weights of proteins by gel filtration on sephadex. Anal. Chem. 35: 1950–1953.

WILLIAMS, J. 1962. Serum proteins and the livetins of hen's egg yolk. Biochem. J. 83: 346–355.

Introduction of Kokanee Salmon (*Oncorhynchus nerka*) into Lake Huron[1]

JOHN J. COLLINS

Research Branch
Ontario Department of Lands and Forests, South Baymouth, Ont.

COLLINS, J. J. 1971. Introduction of kokanee salmon (*Oncorhynchus nerka*) into Lake Huron. J. Fish. Res. Bd. Canada 28: 1857–1871.

An experimental introduction of kokanee salmon (*Oncorhynchus nerka*) into Lake Huron from egg stocks obtained from British Columbia and several western states of the United States began in 1964. From 1964 to 1969, about 5.5 million kokanee (eggs, fry, and fingerlings) were planted. Estimated minimum returns of adults were 9000, 1200, and 4000 in 1967, 1968, and 1969, respectively. Although most of the returns were recorded near planting sites, substantial numbers moved into other areas, in some instances spawning in streams that were not planted. Apparently, most kokanee matured in their 3rd year of life (2+) and their lengths ranged from 18 to 49 cm.

The incidence of lamprey marks on adults was light (1.6% of 4472 examined) but frequencies of marks tended to increase as fish size increased — from 0.5% for 28–32 cm fish to 16.7% for fish over 40 cm long.

Successful stream spawning in 1967 was indicated by the retrieval of live eggs and alevins from redds and the capture of downstream migrant fry. Shore spawning was verified by retrieval of viable eggs from redds in 1969. The potential egg deposition in the two rivers with the largest runs in 1967 was approximately 2.7 million eggs. Fish from British Columbia river-spawning stock spawned both in streams and along shores of South Bay. Since spawning was not restricted to streams, the shore areas of Lake Huron may extend the spawning habitat available to kokanee.

Adult kokanee fed mainly on insects and plankton during August and September. Aerial forms of insects predominated in South Bay kokanee. Dieldrin and DDT residues were moderate, averaging between 0.012 and 0.046 ppm for dieldrin and 0.226 and 1.242 ppm for DDT in whole tissue samples.

Data from South Bay show that the principal species found in association with kokanee were alewife and smelt. The diet of alewife in August indicated possible competition with kokanee.

COLLINS, J. J. 1971. Introduction of kokanee salmon (*Oncorhynchus nerka*) into Lake Huron. J. Fish. Res. Bd. Canada 28: 1857–1871.

L'introduction expérimentale de saumons kokanee (*Oncorhynchus nerka*) dans le lac Huron à partir d'œufs provenant de la Colombie britannique et de plusieurs Etats occidentaux des Etats-Unis a débuté en 1964. De 1964 à 1969, environ 5.5 millions d'individus (œufs, alevins et saumoneaux) ont été ensemencés. Le nombre minimal de retours d'adultes en 1967, 1968 et 1969 est estimé à 9000, 1200 et 4000, respectivement. Quoique la plupart soient revenus dans le voisinage des lieux d'ensemencement, un nombre appréciable de saumons se sont dirigés vers d'autres régions, frayant même, dans certains cas, dans des rivières qui n'avaient pas été ensemencées. La majorité des saumons kokanee semblent atteindre la maturité sexuelle dans la troisième année (2+) alors qu'ils mesurent de 18 à 49 cm de longueur.

L'incidence de marques de lamproies sur les adultes est faible (1.6% des 4472 saumons examinés). Par ailleurs, la fréquence des marques a tendance à augmenter avec la longueur du poisson — de 0.5% chez les saumons de 28 à 32 cm à 16.7% chez ceux de plus de 40 cm.

La capture d'œufs vivants dans les fosses de frayères et d'alevins, aussi bien dans les fosses qu'en aval, dénote le succès du frai en rivière en 1967. La récupération d'œufs viables dans les fosses indique de plus qu'il y eut frai près du rivage en 1969. Le nombre potentiel d'œufs déposés dans les deux rivières où la montée a été la plus abondante en 1967 se chiffre par 2.7 millions environ. Les saumons provenant d'un stock frayant en rivière en Colombie britannique frayent aussi bien en rivière que près des rives de la baie South. Comme le frai n'est pas limité aux rivières, il est possible que les rives du lac Huron constituent une extension d'aires propices au frai du saumon kokanee.

[1]Contribution No. 71-1 of the Ontario Department of Lands and Forests, Research Branch, Maple, Ont.

Printed in Canada (J2007)

Les adultes, en août et septembre, se nourrissent surtout d'insectes et de plancton. Les formes aériennes d'insectes prédominent dans les saumons de la baie South. Des résidus de dieldrine et de DDT sont présents en quantités modérées dans des échantillons de tissus entiers, soit de 0.012 à 0.046 ppm en moyenne pour la dieldrine et de 0.226 à 1.242 ppm pour le DDT.

D'après les données recueillies dans la baie South, le gaspareau et l'éperlan sont les principales espèces associées au saumon kokanee. Le régime du gaspareau en août suggère une compétition alimentaire possible avec le saumon kokanee.

Received January 7, 1971

THE Ontario Department of Lands and Forests began an experimental introduction of kokanee salmon (*Oncorhynchus nerka*) in Lake Huron in November 1964. This introduction and a similar program in Lake Ontario mark the first attempt to establish kokanee in any of the Great Lakes. The decision to plant kokanee in Lake Huron was based on a feasibility study to which a number of persons contributed (Maher 1964). The principal reason for selecting kokanee salmon was that this form, which was derived from the anadromous sockeye (Ricker 1940), has adapted naturally to freshwater environments. Thus, there was a strong possibility of establishing kokanee populations in Lake Huron without continuing hatchery support.

This paper documents plantings in Lake Huron and the returns of mature kokanee from 1964 through 1969. The size and fecundity of mature fish and the size of their progeny are described. Preliminary ecological observations on natural reproduction, distribution, movements, food organisms, pesticide residues, and associated species are discussed.

Methods

Eggs for the plantings were collected at various sites in British Columbia and the states of Colorado, Montana, and Washington (Table 1). The donor stocks inhabited lakes that ranged in elevation from 61 to 2554 m and in latitude from 40°12′ to 51°00′N. Their spawning periods ranged from September in British Columbia to November and December for Montana and Colorado, respectively. All eggs were taken from river spawning stock except those from Flathead Lake, Montana. The eggs were transported by air express to Ontario, where they were incubated at several hatcheries.

Primary criteria for selecting planting sites were: accessibility, types of river and shore gravel, and the distribution of established commercial and experimental fisheries whose operations could be used to monitor success of the plantings (e.g., research facilities at South Bay).

Kokanee were planted at three developmental stages: eyed eggs, fry, and small fingerlings. Since the stocks originated at diverse geographic locations and several hatcheries cultured the eggs, development during culture varied widely. Therefore, kokanee were planted over a wide range of dates and water temperatures.

Eyed eggs were planted in streams only. A long trench about 30 cm deep was dug parallel to the shore in suitable stream gravel. A metal cylinder, 54 cm in diameter and 72 cm long, was placed vertically in the trench near one end. The gravel surrounding the cylinder was then restored to its original level. Several fist-sized rocks were placed in the depression within the cylinder and 5000–10,000 eggs were introduced. Large stones were then placed over the eggs to protect them and gravel was shovelled in to bring the substrate inside the cylinder to the level of the surrounding creek bed. The cylinder

TABLE 1. Sources of kokanee salmon stocks planted in Lake Huron, 1964–69.

Province or State	Years[a]	Egg collection site	Spawning habitat	Elevation[b] (*m*)
British Columbia	1964–65	Meadow Cr., tributary to Kootenay L.	Stream	532
	1966–67	Eagle R., tributary to Shuswap L.	"	348
Colorado	1964–68	Colorado R., near Granby Reservoir	"	2554
Montana	1964, 1967–68	Flathead L.	Lakeshore	881
	1965	Swan R., tributary to Flathead L.	Stream	884
	1968	McDonald Cr., tributary to Flathead L.	"	1220
Washington	1964–65	Brannian Cr., tributary to Watcom L.	"	61

[a]Eggs were collected in September–October in British Columbia, December in Colorado, November and December in Montana, and November in Washington. Eggs were planted in the year collected, fry and fingerlings in the year following.

[b]Range of latitude was from 51°00′N in British Columbia, to 40°12′N in Colorado.

was then withdrawn, leaving the eggs buried; this procedure was repeated at several points along the trench to complete the planting. The gravel in heavily silted areas was cleaned with a portable fire pump before planting eggs. All eggs were planted in October and November each year.

Fry and fingerlings were transported to planting sites by truck and aircraft. Those transported by air were released from stationary aircraft or were transferred to small boats for shore distribution. Fry were liberated in rivers, along lakeshores, and over shoals. They were usually planted before the yolk sac was fully absorbed. Based on a sample of 229 fish planted in 1967, their fork lengths averaged 22 mm (range 14–25 mm). Fry from eggs obtained in British Columbia were planted in February–March and those from the western U.S. in May–June, at water temperatures ranging from near 0 C in February to 13 C in June. Fingerlings were planted along lakeshores and over shoals. Some were marked by removal of fins before planting. A collective sample of 169 fingerlings from plantings in the years 1967–69 averaged 51 mm in fork length (range 34–66 mm). Most fingerlings were planted in June but others were planted in July, September, and October, at water temperatures ranging from 15.5 C to 19 C.

Data on returns of adult kokanee were based on fish taken by anglers, experimental nets, counting weirs set in rivers, and commercial nets. Anglers caught fish mainly by snagging them when concentrated in the rivers in the fall. Kokanee were taken in routine experimental netting by the Research Branch of the Ontario Department of Lands and Forests. This gear consisted of gillnets ranging in mesh size from 25 to 114 mm (stretched measure) and poundnets. Some exploratory sets of gillnets were made at the surface and midwater depths specifically to catch kokanee. Water temperatures were recorded from bathythermograph casts or thermistor readings each time gillnets were set.

Temporary counting weirs were installed at two Manitoulin Island streams in the fall: Manitou River in 1967–69 and Blue Jay Creek in 1968–69. Each weir consisted of a fence leading from each shore to a trap, 1.2 × 1.2 × 2.4 m, in midstream. Kokanee moving upstream entered the trap through a tunnel that tapered to a 20 × 20-cm opening. Both weirs were constructed of wooden frames and wire mesh that varied in size but was never larger than 2.5 × 3.8 cm. In 1969, the fence webbing was replaced by 6.5-mm steel rods spaced vertically 2 cm apart. Because of this modification, a few small kokanee (under 19 cm long) avoided capture by passing through the fence.

A reward was offered for specimens taken incidentally in commercial fishing gear. Kokanee were captured in large mesh "whitefish" nets (114–121 mm), "chub" nets (64 mm stretch measure), poundnets, and trapnets.

Numbers of kokanee reported to be spawning in streams and along the Ontario shores of Lake Huron were usually based on visual observations made by personnel of the Fish and Wildlife Branch of the Department. Contact was maintained with agencies on the United States shores of Lake Huron through progress reports to the Great Lakes Fisheries Commission.

Kokanee were counted as returns only if they were judged to be mature or maturing by the following criteria: elongation of jaws in males, red pigmentation in both sexes, and gonad development when specimens could be examined. Fish captured before August 25 each year (arbitrarily set as the earliest date morphological changes could be recognized) were not counted.

Data on fork lengths (in millimeters), numbers of finclips, and lamprey marks were taken for all samples. Age data were based on recaptures of marked fish or were estimated from planting records. The scale method was not used because of extensive scale resorption in mature fish.

To assess success of spawnings, eggs and alevins were retrieved from redds in Blue Jay Creek on December 19 and 20, 1967. Because of winter conditions, sampling was restricted to seven locations along a 24-m stretch of stream (total area of 2.6 m^2 of gravel). Samples were taken to an approximate depth of 30 cm by using a 0.34-m^2 Surber sampler.

Downstream migrant fry were sampled by fine mesh nets installed in Blue Jay Creek in 1968. Each net consisted of a 3-mm mesh bag, 86 cm long, tapering to a point from a 30 × 61-cm wooden frame. The nets were supported in the stream by channel iron frames that held from one to three nets in a vertical series. Each series of nets sampled a 61-cm wide section of the stream from surface to bottom. The nets were set 17 times during the period from April 21 to June 7.

Planting Schedule

Most sites (Fig. 1) were planted with stocks from several sources (Table 2). However, discrete stocks were consistently planted at certain sites, for example, the Michael Bay area was planted only with British Columbia stocks. Although the sites were widely distributed, most of the kokanee (81–100% of each year-class) were planted within a band 70 km wide running from the southeast end of Manitoulin Island through the Bruce Peninsula to the Nottawasaga River (site 19)[2].

The largest plantings were made at South Bay (4). These averaged 423,000 kokanee annually (eggs, fry, and fingerlings combined) with a range in year-class sizes from 52,000 to 727,000. The largest plantings of single year-classes outside of South Bay were made at Manitou River (1) and Owen Sound (12–15), with an average of 180,000 and 164,000, respectively.

The summation of numbers planted (Table 2) shows that the first three year-classes planted in Lake Huron were roughly comparable in magnitude. The size of the 1967 year-class was larger than that of 1965 and 1966 year-classes because of an increase in egg and fry plantings; however, this increase was probably offset by a reduction in the number of fingerlings planted that year. The size of plantings in 1968 and 1969 was severely reduced because of a shortage of eggs. Plantings were discontinued at certain sites in 1968 to evaluate natural reproduction at those locations.

[2]Planting site numbers (Fig. 1) are given (in parentheses) when location names first appear in text.

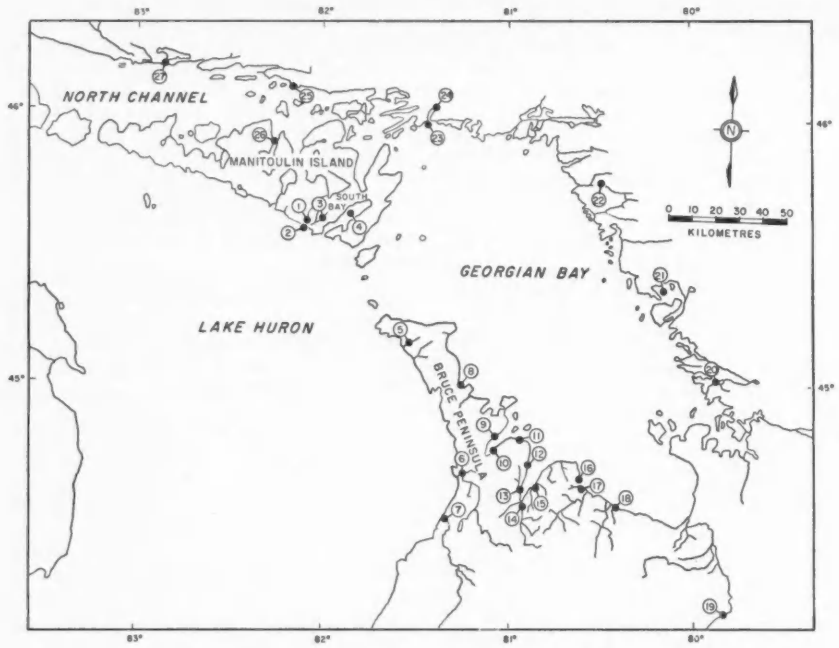

FIG. 1. Locations of planting sites. Site numbers correspond to numbers in Table 2.

Returns of Adults

Annual returns of adult kokanee ranged from 273 to 9062 fish (Fig. 2). The small number in 1966 comprised mainly males; of an estimated 130 adults observed in Manitou River, 86% were males. Although this sex ratio was based on a sample of 52 fish caught by angling, no apparent bias was introduced. Similar ratios, based on visual observations only, were found at Oxenden Creek (10), where 50 fish spawned. The percentages of males, which were estimated several times during this run, ranged from 70 to 90%.

Most of the returns occurred in the Manitoulin Island–Bruce Peninsula area, where plantings were concentrated. Spawning aggregations in 1967–69 were observed mainly in rivers and occasionally along shores. The three largest runs occurred in September 1967 at Blue Jay Creek (3), Manitou River, and Oxenden Creek. Blue Jay Creek was not stocked until 1967 (Table 2). Therefore, the estimated 5000 spawners probably came from either or both of two plantings in 1965 — 120,000 eggs in the adjacent Manitou River and 54,000 fingerlings in Michael Bay (2), into which both streams flow. The same plantings probably supported the Manitou River run (2311 fish). The run of 984 fish in Oxenden Creek was probably supported by the planting of 28,000 fry and 11,000 fingerlings in that creek in 1965.

The next largest returns of kokanee occurred in 1969: a shore spawning run in South Bay and a river run at Colpoy Creek (southwest of site 9). The number of spawners reported for South Bay (1304 fish) comprised only fish that were captured by experimental and commercial gillnets and did not represent the total spawning population. From the percentage of finclipped fish in this sample, it was estimated that 63% of the fish captured were survivors of a fingerling planting (Table 2) in South Bay in 1967. The remainder may have come from several plantings made in previous years. The 724 fish in Colpoy Creek were counted during a spawn-taking operation in late September. Since this stream had never been stocked, the run probably developed from plantings of 30,000 fry in Colpoy Bay (9) and Big Bay (11) in 1967.

Very few kokanee were observed along the northeast shore of Georgian Bay despite plantings of the 1965–67 year-classes totaling 570,000 kokanee (eggs, fry, and fingerlings, Table 2, sites 20–22). There is no obvious explanation for the apparent failure of these plantings.

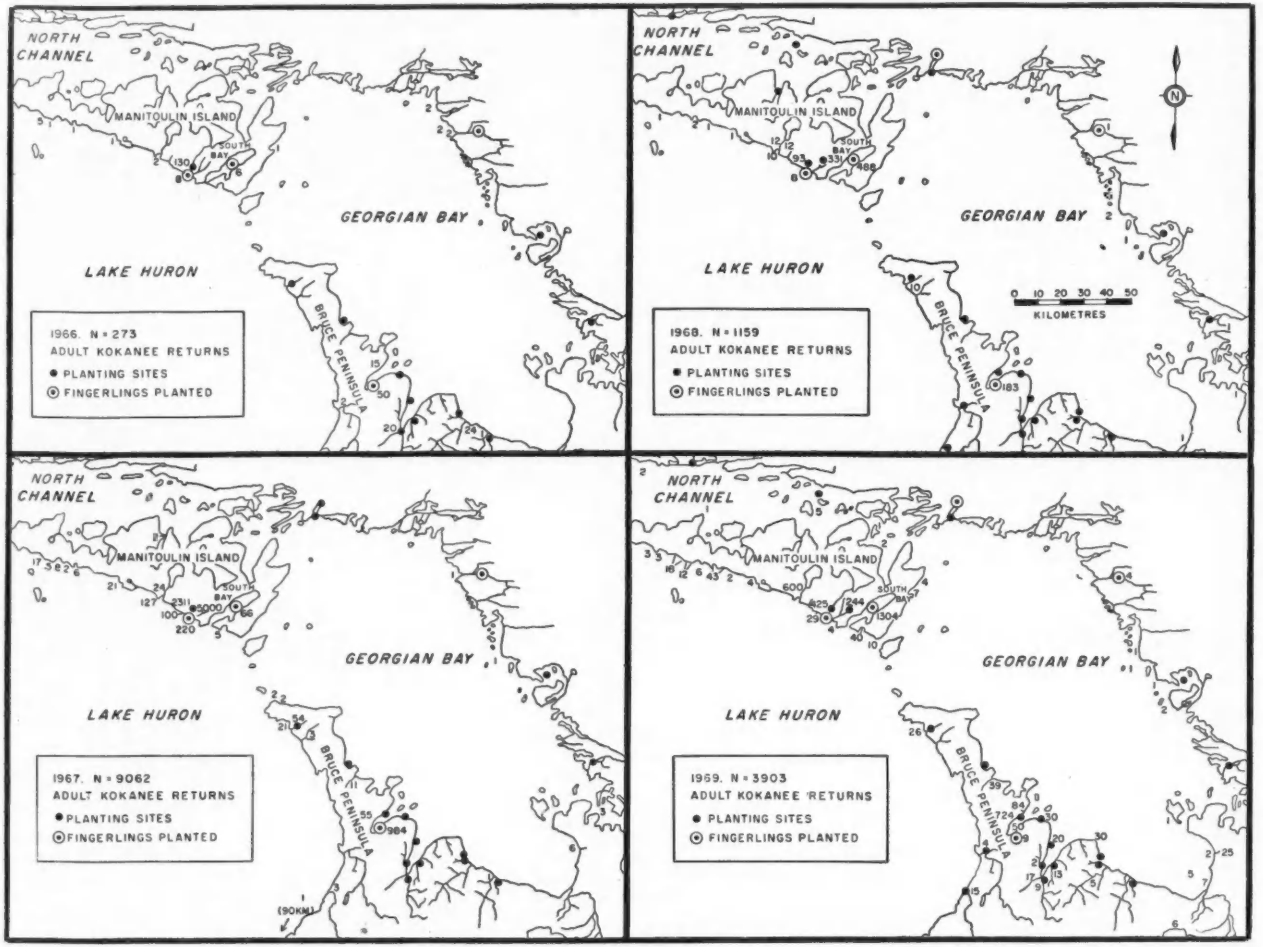

FIG. 2. Locations and numbers of adult kokanee returns in the fall (1966–69). Sites of plantings from which they could have originated are represented by solid dots (eggs and fry), and circled dots (fingerlings). Total returns (N) include all mature kokanee captured or observed.

TABLE 2. Numbers (rounded to nearest thousands) of kokanee, according to year-class[a] and origin[b] of stock, planted at various sites in Ontario waters of Lake Huron and tributaries, 1964–69. Percentages of fingerlings released in South Bay that were marked are in footnotes.

Location	Site no.	1965	1966	1967	1968	1969	Total
			Eyed eggs B				
Manitou R.	1	120	100	140	–	–	360
South Bay	4	60	50	–	–	–	110
Willow Cr.	5	30	50	60	–	–	140
Sauble R.	6	–	–	80	–	–	80
Saugeen R.	7	–	–	180	–	–	180
Sydenham R.	14	50	100	180	–	–	330
Bothwell Cr.	15	20	25	20	–	–	65
Indian Cr.	18	20	25	–	–	–	45
Go Home R.	20	60	50	80	–	–	190
Chickenechine R.	23	–	50	100	–	–	150
Kagawong Cr.	26	–	–	42	–	–	42
Lauzon Cr.	27	–	–	42	–	–	42
Total		360	450	924			1734
			Fry				
Manitou R.	1	–	–	180 B	35 H	–	215
Blue Jay Cr.	3	–	–	78 B	–	–	78
South Bay	4	490 BWC	249 MC	488 BC	–	141 CM	1368
Sauble R.	6	–	–	–	60 M	–	60
Saugeen R.	7	–	–	–	90 M	–	90
Lion's Head	8	116 M	116 C	100 C	–	–	332
Colpoy Bay	9	–	30 C	15 B	–	–	45
Oxenden Cr.	10	28 M	–	–	–	–	28
Big Bay	11	19 M	18 W	15 B	–	–	52
Owen Sound shore	12	24 M	–	–	–	–	24
Balmy Beach	13	–	24 WC	–	–	–	24
Bothwell Cr.	15	24 M	24 W	–	–	–	48
Meaford Shoal	16	24 M	–	30 C	–	–	54
Centreville Cr.	17	–	24 W	–	–	–	24
Nottawasaga R.	19	–	–	–	–	178 M	178
Mowatt Is.	21	110 WC	100 W	82 C	–	–	292
George L.	24	–	59 W	–	–	–	59
Richies Rock	25	–	–	38 C	–	–	38
Total		835	644	1026	185	319	3009
			Fingerlings				
Michael Bay	2	54 B	–	–	–	–	54
South Bay	4	177 B[c]	219 B[d]	155 B[e]	52 M[f]	43 C[g]	646
Oxenden Cr.	10	11 B	–	–	7 G	–	18
Byng Inlet	22	46 B	42 B	–	–	–	88
George L.	24	–	–	22 B	–	–	22
Total		288	261	177	59	43	828
Grand total		1483	1355	2127	244	362	5571

[a]The year in which fry developed to the free-swimming stage.

[b]General origin of stocks are coded by the following letters: B, British Columbia; C, Colorado; M, Montana; W, Washington; H, fry hatched from eggs taken from fish that spawned in the Manitou River (Lake Huron) in the fall of 1967; and G, fingerlings hatched from eggs taken from spawners in Colpoy Creek (Georgian Bay) in 1967.

[c]177,100 planted, 0.4% marked by right ventral and adipose finclips.

[d]219,300 planted, 5.3% marked by left and right ventral fin clips.

[e]154,700 planted, 26.5% marked by left pectoral finclip.

[f]51,600 planted, 100% marked by right pectoral finclip.

[g]43,000 planted, 100% marked by right ventral finclip.

Movements of Planted Stock

Since the planted fish were usually seen only twice during their life span, at time of planting and when they returned to inshore areas at maturity, only gross movements can be described. The spawning runs in streams that were not planted, e.g., Mindemoya River (15 km west of site 2) and Colpoy Creek, indicate that considerable movement occurred.

The recapture pattern in 1969 (Fig. 3) of adults planted as fingerlings in South Bay in 1967 (26.5% finclipped) suggests that their movements were limited to Manitoulin Island shore areas. The percentage of marked adults in catches along the south shore of Manitoulin Island declined as the distance from the planting site increased. Estimated contributions to catches declined from 63% in South Bay to 29% at Burnt Island, 80 km to the west of the planting site.

Length and Age at Maturity

All mature kokanee observed in 1966 were survivors of the first plantings — the 1965 year-class. These 1+ fish had nearly completed their 2nd year of life (about 23 months in age from time of egg fertilization). Their lengths ranged from 21 to 33 cm with a mode at 25 cm (Fig. 4) and most were precocious males. The presence of precocious 1+ fish is indicated by the high percentage of males among fish less than 32 cm long from Lake Huron proper (open histograms), 70% in 1968 and 68% in 1969, and among fish less than 25 cm long for South Bay kokanee (solid histograms), 70, 74, and 75% in 1967, 1968, and 1969, respectively.

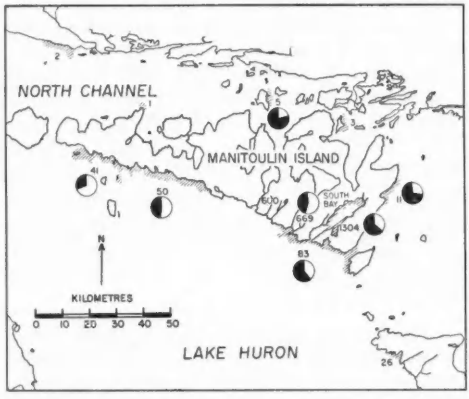

Fig. 3. Distribution of returns (numerals) for the Manitoulin Island area in 1969, and percentages contributed from a plant of 155,000 fingerlings (26.5% finclipped) in South Bay in 1967 (dark portions of circles). Hatched areas are locations of catches in nets. Marked fish were observed in Mindemoya River but the percentage marked (of 600 fish) is not known.

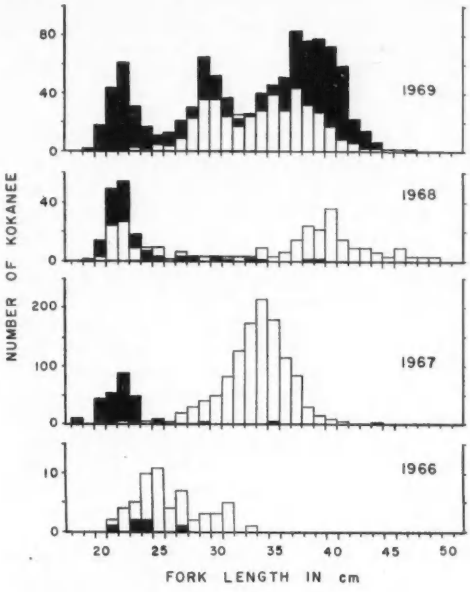

Fig. 4. Length–frequency distributions for mature kokanee in years 1966–69. Open bars, fish from Lake Huron proper (anglers' catches in 1966 and Manitou River weir catches in 1967–69); solid bars, experimental gillnet catches in South Bay. To facilitate comparison, the number of kokanee for South Bay in 1967 is multiplied by a factor of 5 and the Lake Huron sample in 1968 by a factor of 3.

The lengths of known age 2+ fish in 1969 (225 finclipped recaptures) ranged from 25 to 44 cm in Lake Huron proper, and from 20 to 44 cm in South Bay. The length distributions of these fish (included in Fig. 4) were multimodal, as were those of the fish in general in 1969. The 1967 histogram for kokanee from Lake Huron proper with a mode at 34 cm (range 20–44 cm) probably represented 2+ fish. This premise is supported by the nearly normal sex ratio (52% males), which suggests that precocious 1+ fish were not abundant in this distribution. Mature kokanee from Georgian Bay were similar in size to those from Lake Huron proper. In 1969, the only year with comparable data, the length distribution of 664 fish from Colpoy Creek was approximately symmetrical with a modal length of 37 cm (E. E. Ackert personal communication).

Most kokanee apparently matured in their 3rd year of life (2+). This premise is supported by the large spawning runs in 1967 that followed the small runs of precocious fish in 1966; e.g., the returns to Oxenden Creek (planted only in 1965) in the years 1966–69 were 50, 984, 183, and 9 fish respectively (Fig. 2). Further, marked-fish recaptures in 1969 indicate that at least 63% of the spawners in South Bay were age 2+ fish. Survivors of the 1965 year-class may have been present in the 1968 and 1969 returns (Fig. 4) at age 3+ and 4+, respectively, but there is no conclusive evidence that the larger fish belonged to these age classes.

Although the size of kokanee from Lake Huron proper varied in the years 1967–69, most fish were in the 28–40-cm length range, with an overall range of 20–49 cm. South Bay kokanee tended to be smaller in 1967 and 1968, but were comparable in 1969.

The size of mature kokanee in Lake Huron proper compared favourably with that of mature kokanee in western lakes. Averett (1966) reported modal fork lengths of 30 and 33 cm for spawners in Odell Lake, Oregon. Robbins (1966) reported mean total lengths of 31.8 and 33.0 cm for spawners in Flathead Lake, Montana, in 1962 and 1963, respectively. Mean fork lengths of mature kokanee in Nicola Lake, B.C., ranged from 22.6 to 29.0 cm in 1958–63, (Lorz and Northcote 1965) and the average lengths for three races of kokanee in Kootenay Lake, B.C., ranged from about 18.5 to 24.5 cm in 1951–54 (Vernon 1957).

Lamprey Parasitism of Kokanee

In 1967–69, 4472 adult kokanee from Lake Huron waters were examined for marks resulting from attacks by sea lamprey (*Petromyzon marinus*). Of these, 72 fish (1.6%) bore lamprey marks in the form of fresh wounds or healed scars. The incidence of marks was relatively low even though all fish were sampled in early fall (August 25 onward), a period when marking frequencies were high in species such as splake (*Salvelinus fontinalis* × *S. namaycush*) in Lake Huron proper (Berst and Spangler 1970) and lake whitefish (*Coregonus clupeaformis*) in Georgian Bay (Cucin and Regier 1965).

The incidence of marks increased as fish length increased in kokanee from the Manitoulin Island area. This trend may be seen in the 1969 data (1967 fish), which covered the entire range of sizes attained by kokanee in Lake Huron. Only two out of 283 fish less than 32 cm long bore marks. Percentages of marked fish increased from 0.5 for 389 fish 28.0–31.9 cm long, through 2 for 393 fish of 32.0–35.9 cm, 3 for 573 fish of 36.0–39.9 cm, and 3.9 for 311 fish of 40.0–43.9 cm, to 16.7 for 18 fish of 44.0–47.9 cm. A similar trend was observed in splake (Berst and Spangler 1970), lake trout (*Salvelinus namaycush*) (Budd and Fry 1960), and rainbow trout (*Salmo gairdneri*) (Berst and Wainio 1967).

Budd and Fry (1960) found that for lake trout in South Bay, only 3% of fish less than 43 cm long bore marks and, despite heavy lamprey predation, survival of trout to age 4 (larger than 43 cm) was quite good.

The relatively small size of kokanee probably accounts for the low incidence of lamprey marks. In contrast, coho salmon (*Oncorhynchus kisutch*) in Lake Huron, which are much larger at comparable ages, were heavily marked. Brubacher (1970) reported an average marking incidence of 73% for mature coho (average weight 2.8 kg) observed in streams in 1969.

Natural Reproduction

In 1967 and 1968, the major spawning runs in streams began in mid-August and ended in the 1st week of October. Most kokanee probably spawned in the 3rd week of September, but a small second run of 92 fish developed in Oxenden Creek on October 2, 1968. In 1969, river runs began in mid-September and ended in mid-October; major spawning probably occurred about September 30.

The shore spawning run in South Bay, which was observed for the first time in 1969, occurred at the same time as river runs that year. Examination of gonads showed that most fish spawned between September 24 and October 7, with peak spawning activity on October 2. All specimens examined on October 15 were spent.

Although late spawning stocks were introduced, no spawning runs were observed after mid-October in any year.

Reproductive Potential

The relation between the length of fish and number of eggs (Fig. 5) was computed according to the relation $F = aL^b$ suggested by Gerking (1967). Computed by the least-squares method, the relation may be expressed as:

$$\log_e F = -10{\cdot}936 + 3{\cdot}036 \log_e L,$$

where F is number of eggs and L is fork length in millimeters. The correlation coefficient was 0.86.

The potential egg production for the Manitou River and Blue Jay Creek spawning runs was estimated for each site as follows: the number of females within 2-cm length intervals was multiplied by the number of eggs (read from the regression) for the midpoint of each interval and the products

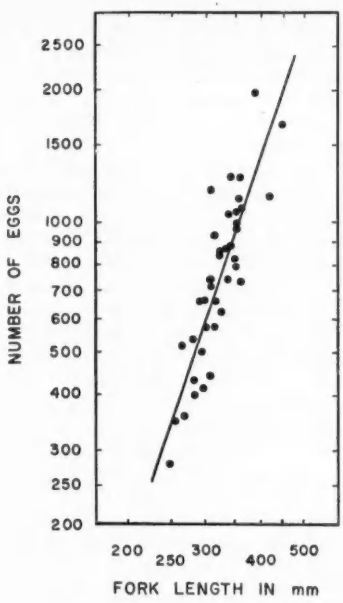

FIG. 5. Length–egg relation (fecundity) of kokanee from Lake Huron proper (taken along the south shore of Manitoulin Island) in 1967 and 1968). The dots represent individual fish; egg counts of 39 ovaries.

were summed. Estimated numbers of eggs (thousands) carried into the two spawning sites in the years 1967–69 (potential year-classes in parentheses) were:

	1967 (1968)	1968 (1969)	1969 (1970)
Manitou R.	765	37	189
Blue Jay Cr.	1914[a]	31	76
Total	2679	68	265

[a]Based on an estimated 5000 fish assuming same sex ratio and length distribution as for the Manitou River run.

The potential egg deposition in 1967 of 2.7 million eggs at the above spawning sites should have supplemented to some extent the reduced plantings of the 1968 year-class (Table 2). The actual number of eggs deposited in the stream gravels may have been considerably smaller than this because mortality of river kokanee to angling was thought to be considerable in 1967. Predation of spawning kokanee by great blue herons (*Ardea herodias*) was observed in shallow areas of Blue Jay Creek in 1967, but the loss of eggs to this predator was probably slight.

River Spawners

Successful spawning was documented for the Blue Jay Creek kokanee by samples of eggs from redds on December 19 and 20 in 1967 and a sample of downstream migrant fry in the spring of 1968.

Of 131 eggs and alevins retrieved from the gravel, 56% had survived to the eyed egg stage and 44% of the 32 alevins found were alive on the sampling date.

Subsequently, 38 of the eggs collected in the sample were incubated at laboratory water temperatures of 2 C and all hatched by January 29, 1968. Since the stream water was colder (near 0 C) in this period, all eggs remaining in the redds would not have hatched by January 29. These data show that eggs hatched over a period ranging from before December 20, 1967, to well after January 29, 1968.

The capture of 866 fry in nets near the Blue Jay Creek mouth in the spring of 1968 confirmed that natural progeny in that stream survived to the advanced fry stage. Catch data (not given here) indicated that fry were moving out of the stream before the first nets were lifted (April 21) and that the migration was complete by May 29, 1968.

The length–frequency distribution of the fry (Fig. 6) shows that some fed extensively during their movement downstream and were older than the majority of fry when captured. Most fry caught in the period April 21–May 15 (open histograms) were in the 19–28-mm length range. As their yolk sacs were not completely absorbed, these fry ap-

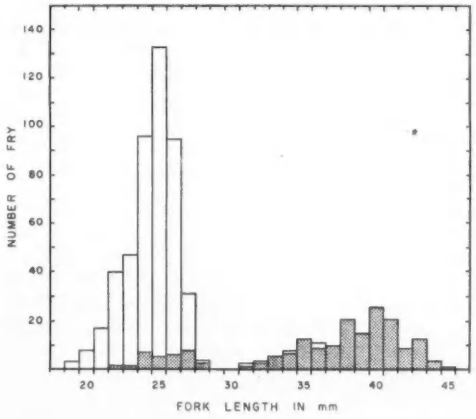

FIG. 6. Length–frequency distribution of 639 kokanee fry taken in nets 0.8 km upstream from the mouth of Blue Jay Creek, April 21–June 7, 1968. Open bars, fry captured up to May 15; solid bars, fry captured after May 15.

parently moved downstream shortly after emergence from the gravels. About 97% of the large fry (solid histograms) were captured in the last 2 weeks of the migration and had apparently remained in the stream for some time after emergence.

Shore Spawners

Successful shore spawning in South Bay was documented by the retrieval of eggs from redds in 1969. Eggs were collected on October 14 by a scuba diver using a syringe and on November 5 by using a diaphragm pump operated from a boat. A total of 365 eggs (combining both samples) was collected and 25% were alive when examined.

All live eggs collected on November 5, about 35 days after the peak spawning period, had developed to the eyed stage. Further samples were not collected from the Bay, but 32% of the live eggs collected survived to the swim-up stage[3] at the laboratory; the eggs were cultured in gravel.

[3]Emergence from the gravel was completed by May 11, 1970.

Diet

Of the kokanee examined in 1966–67, 53 from South Bay and 130 from Lake Huron contained some food, often only fragments of insects. Samples from South Bay were taken in August and those from Lake Huron in August and September. Most fish were taken close to shore (all within 3 km).

Insects were the major component of the kokanee diet, occurring in 90% of the stomachs (Table 3). Aerial forms were found more frequently in South Bay fish (89%) than in Lake Huron fish (62%), whereas the reverse was true for aquatic forms. The principal insects in South Bay were the Homoptera, chiefly aphids (Aphididae) and leafhoppers (Cicadellidae), and the Diptera, midges (Chironomidae) and fungus gnats (Mycetophilidae).

In Lake Huron fish, aquatic Diptera pupae occurred most frequently, the main aerial forms being of the Lepidoptera, chiefly leafminers (Lyonetiidae). Most insects eaten were small, less than 10 mm long.

Plankton, which occurred almost as often as insects in South Bay fish (79%), were found in only

Table 3. Percentages[a] of kokanee stomachs containing principal food items. Samples were from Lake Huron in August and September and from South Bay in August, 1966–67.

Food item	Lake Huron		South Bay		Total
	Aquatic	Aerial	Aquatic	Aerial	
No. containing food	130		53		183
Insecta	55.4	62.3	32.1	88.7	90.2
Homoptera		12.4		69.8	
Psocoptera		1.5		58.5	
Hymenoptera		9.2		56.6	
Lepidoptera		35.4		15.1	
Diptera	51.5	25.4	30.2	43.4	
Hemiptera	2.3	6.9	3.8	43.4	
Coleoptera	0	3.8	1.9	32.1	
Trichoptera	4.6	14.6	1.9	15.1	
Ephemeroptera	6.9	5.4	7.5	9.4	
Plankton	32.3		79.2		45.9
Cladocera					
Holopedium	8.4		62.3		24.0
Polyphemus	21.5		15.1		19.7
Daphnia	2.3		56.6		18.0
Leptodora	0.8		28.3		8.7
Copepoda					
Cyclops	0.8		52.9		15.8
Diaptomus	1.5		22.6		7.7
Other	21.5		54.7		31.1

[a]On basis of number of stomachs containing food.

32% of Lake Huron fish. The cladocerans *Holopedium* and *Daphnia* and the copepod *Cyclops* were the main plankters in South Bay fish, and the cladoceran *Polyphemus* in Lake Huron fish.

Remains of fish larvae, probably alewife (*Alosa pseudoharengus*), were among the items not listed in Table 3. These occurred in two South Bay kokanee stomachs and one from Lake Huron.

For kokanee of Nicola Lake, B.C., Northcote and Lorz (1966) found that chironomid pupae and the plankters *Leptodora*, *Daphnia*, and diaptomids were prominent food items during August. For other western lakes, Chapman et al. (1967), Chapman and Fortune (1963), and Clemens et al. (1939) each reported aquatic forms of Diptera in kokanee stomachs, although plankters were usually prominent. Ricker (1937) recorded that a few stomachs of "residual" sockeye contained adult chironomids and terrestrial insects, although most sockeye stomachs contained plankters.

Although Lake Huron kokanee fed on plankters similar to those taken by western kokanee, their diet differed markedly. South Bay kokanee, in particular, fed extensively on aerial forms of terrestrial and aquatic insects in August. This tendency persisted, even though aquatic insects were probably abundant at that time of year (Cooper MS 1964). This predominance of aerial forms in their diet may indicate surface feeding behaviour, but the insects could have been picked up off the bottom or in midwater.

Pesticide Residue

None of the DDT residue concentrations recorded for kokanee in Lake Huron is presently considered excessive with regard to their use for human consumption. Further, there was no indication of DDT poisoning in Lake Huron kokanee fry (from egg viability tests) when their yolk sac absorption was completed.

In 1968–69, 18 South Bay kokanee (averaging 78 g in weight) and 21 from Lake Huron proper (averaging 700 g) were examined for pesticide residues. Total DDT and dieldrin concentrations (ppm) in whole tissue samples averaged as follows (ranges in parentheses):

	Total DDT	Dieldrin
South Bay	0.226(0.06–0.43)	0.012(0.003–0.034)
L. Huron	1.242(0.19–2.60)	0.046(0.013–0.244)

The concentrations were apparently higher in kokanee from Lake Huron than in those from South Bay. Although highly variable, the DDT concentrations were similar for ciscoes (*Coregonus artedii*) lake whitefish, and chub (*Coregonus* spp.) from Lake Huron that were tested at the same laboratory.

Thermal Distribution of South Bay Kokanee

Gillnet catches in the May–September period indicated that kokanee were most abundant at water temperatures from 8.5 to 12.4 C (Table 4). Substantial numbers also occupied warmer waters (18.5–20.4 C) in August and September.

The catches from early May to mid-July suggested that kokanee were found at water temperatures above the 10 C isotherm. Since thermal stratification in South Bay is generally well established by June 7, with the 10 C isotherm at a depth of 15 m (McCombie 1967), the fish were in the warmer inshore waters in June. After mid-July, kokanee tended to occupy the region of the thermocline (8.5–14.4 C), but they were also found in a wide range of water temperatures. Most occurred in the 6.5–20.4 C temperature range. Since the maximum surface temperatures occur by the 1st week of August (McCombie 1967), and prevail during the month, prespawning kokanee encounter the warmer temperatures at inshore areas toward which they moved in late August.

At Elk Lake, Oregon, Chapman et al. (1967) found that kokanee occupied deeper waters during August, when the temperature of the epilimnion exceeded 18.3 C. Although South Bay kokanee occupied cooler waters in August, they were also present in the warm surface layers. Data on South Bay kokanee generally agree with observations made by Horak and Tanner (1964), who noted that kokanee of Horsetooth Reservoir, Colorado, occupy waters with a broad temperature range and that most were within and above the thermocline.

Associated Species

In South Bay, alewife and rainbow smelt (*Osmerus mordax*) were consistently caught along with kokanee in experimental gillnets from April to September (Table 5). Yellow perch (*Perca flavescens*) and white sucker (*catostomus commersoni*) were taken in August and September, the latter species in May as well. Trout-perch (*Percopsis omiscomaycus*) and spottail shiners (*Notropis hudsonius*) were caught with kokanee in the spring and fall. Several other species were taken occasionally, but catches of splake were of particular interest, since splake may affect the status of kokanee directly by predation or indirectly by feeding on associated species. Berst and Spangler (1970) showed that alewife and smelt were major components of splake diet.

TABLE 4. Catches per unit of effort (CUE)[a] of kokanee in gillnets set in South Bay at various temperatures during the summers of 1967–69.

Temp at net (C)	Apr. 29–May 18	May 19–June 7	June 8–27	June 28–July 17	July 18–Aug. 6	Aug. 7–26	Aug. 27–Sept. 15	Sept. 16–Oct. 5	No. fish	Total effort	Total CUE
20.5–22.4					0.0	0.0	2.0		2	3.0	0.7
18.5–20.4					0.0	10.0	13.0		34	4.0	8.5
16.5–18.4					0.5	2.3	4.5	12.0	17	7.5	2.3
14.5–16.4			0.0	1.0	0.0		52.0	1.0	27	6.0	4.5
12.5–14.4			0.5	0.7	8.0	5.5	4.0	0.0	26	10.5	2.5
10.5–12.4		18.0	0.3	0.0	16.0	7.2	13.5	2.8	85	10.5	8.1
8.5–10.4		2.0			4.2	0.4	9.4	14.0	65	9.5	6.8
6.5–8.4		0.7	0.0	0.0	0.0	2.0	0.3	26.0	94	22.0	4.3
4.5–6.4	0.8	0.0	0.0	0.0	0.0	0.0	0.0	27.7	6	15.5	0.4
2.5–4.4	4.8								12	2.5	4.8
No. fish	18	14	4	2	27	56	118	129	368		
Total effort	10.0	8.5	10.0	4.5	11.0	16.0	22.0	9.0		91.0	
Total CUE	1.8	1.6	0.4	0.4	2.5	3.5	5.4	14.3			

[a]One unit of effort consisted of a gang of gillnets composed of 91-m panels of the following mesh sizes: 38, 44, 51, 57, and 64 mm (stretched measure).

TABLE 5. Ratios of major species to kokanee taken in experimental gillnets in South Bay in 1967–68.

Species	Month						Overall ratio
	Apr.	May	June	July	Aug.	Sept.	
Alewife	33.0	7.3	10.8	4.8	4.4	16.6	8.6
Rainbow smelt	4.0	19.7	1.3	1.0	3.1	6.8	4.3
Yellow perch					0.2	7.8	2.5
White sucker		21.3			0.3	2.8	1.2
Trout-perch	23.0	0.7			*[a]	0.2	0.3
Spottail shiner		0.3			*	0.9	0.3
Splake		1.0		0.1	0.2	0.1	0.1
Rock bass					*	0.4	0.1
Lake whitefish					0.1	0.2	0.1
Chub[b]	4.7				*	0.1	0.1

[a]Ratio < .05.
[b]Coregonids other than lake whitefish, round whitefish, or cisco.

Interpretations of these observations must take into account the relative abundance of associated species; most had declined in abundance during the mid-1960's. By 1964, the alewife population had reached a high level of abundance in South Bay (Coble 1967). In succeeding years, the size of the population apparently declined, as poundnet catches in 1968 were about 22% of those in 1964 (Anonymous 1968). Poundnet catches also indicated that white sucker and yellow perch were declining in abundance over the same period. Smaller species of fish, such as trout-perch and spottail shiners, may also be important cohabitants of kokanee, at least in the spring and fall. Trout-perch, although not commonly taken in gillnets, are vulnerable to small trawling gear, and were quite abundant in South Bay (Reckahn 1970).

The diet of alewife suggests that there could be interspecific competition with kokanee at least for part of the year. Analysis of 43 stomachs from alewives caught along with kokanee shows that, in August, alewives fed on many of the same species of plankton as kokanee. The principal food items in alewife, expressed as percent of the stomachs in

which they occurred, were as follows: *Daphnia* 91, *Bosmina* 79, *Holopedium* 67, *Diaptomus* 91, and *Cyclops* 88. If competition for food does occur, kokanee may have an advantage in that they feed on a wide variety of insects as well as on plankton. The extent of interaction among species of fish that occur in the same gillnet is not known. The fish are associated only in the sense that they all moved through waters being sampled by stationary gear.

Discussion

Kokanee were introduced into Lake Huron at a time when the ecosystem was in an exceptional state of flux. In the first half of the 1960's, exotics, such as sea lamprey, smelt, and alewives, were abundant. As discussed by Smith (1968), many stocks that were readily useful to man had declined and were succeeded by less desirable species. One major predator, the lake trout, was virtually extinct, and planktivores, such as cisco, and several species of chub had declined severely.

Concern for the imbalance in the ecosystem, notably the absence of climax predators and the abundance of alewife and smelt, has led to a comprehensive rehabilitation program by the United States and the Province of Ontario. Its chief objectives are control of sea lamprey and introduction of splake as a primary predator and kokanee as a planktivore. As well as being a potentially valuable fishery resource, kokanee may serve a secondary function as a forage fish. In addition to these measures, in 1968, the State of Michigan introduced coho and chinook salmon (*Oncorhynchus tshawytscha*) to Lake Huron (Anonymous 1969).

Thus far, kokanee plantings have been moderately successful, the minimum size of spawning populations ranging from 1100 to 9000 fish in 1967 through 1969. If most of the spawners belonged to the 2+ age class, returns in those years directly corresponded to numbers of the 1965, 1966, and 1967 year-classes planted. Since numbers of these year-classes planted were similar, the returns may be rough indices of survival: 9062 (1965 year-class), 3903 (1967), and 1159 (1966). Factors in the apparent eightfold difference in year-class survival are not known.

The relatively small size of plantings (about 5 million kokanee in the 1964–69 period) in relation to the vast area of Lake Huron is not considered a serious handicap. Annual plantings of a similar size are planned to continue until 1972. Several exotics — sea lamprey, smelt, and alewife — became established in Lake Huron principally because environmental conditions were suitable for their survival and not because massive numbers were introduced.

The response of kokanee to their new environment has been satisfactory and shows considerable flexibility — notably their tolerance of a wide range of temperatures (in South Bay) and their utilization of a variety of food organisms. One stock (planted as fingerlings in South Bay in 1967) has demonstrated a propensity to spawn both in rivers and along lakeshores. Since spawning was not restricted to streams, the use of shore areas may extend the spawning habitat available to kokanee and improve their chances of becoming permanently established in Lake Huron.

The size of Lake Huron kokanee at maturity and their table quality would be acceptable to angling and commercial fishery interests if they were caught before the spawning season (spawning fish are unpalatable late in the season). The incidence of lamprey attacks and the level of pesticide residues observed in kokanee do not appear to be problems.

The main approach to the introduction was to inject a broad base of genetic variation by drawing on donor stocks from a variety of sources; the donor lakes ranged in latitude from 40°12′ to 51°00′N. Nelson (1968) reported that indigenous kokanee populations ranged from about 43°45′ to 60°20′N in the Pacific drainages of North America. With respect to latitude, Lake Huron (between 43°00′ and 46°20′N) lies within the southern part of their natural range. Kokanee have been introduced within these lower latitudes in several eastern states, including New York (Webster and Flick 1960) and Vermont (Buss MS 1957). The approximate elevations of donor lakes ranged from 61 to 2554 m, compared with 177 m for Lake Huron. It follows that environmental characteristics associated with these ranges in latitude and elevation would vary considerably, and these variations may be reflected in the stock.

Genetic variation in the planted stock would increase the probability of successful introduction in Lake Huron because the lake is large and presents a variety of habitats and subclimatic areas. The geological structure of Lake Huron shores ranges from the Devonian, Silurian, and Ordivician rocks of the main basin to Precambrian rocks of the east shore of Georgian Bay and the north shore of the North Channel. Because of variation in its physical properties, certain areas might provide a more suitable habitat than others, leading to the establishment of discrete populations of kokanee. Subpopulations are characteristic of other species in Lake Huron; for example, lake whitefish populations in several areas are regarded as discrete (Budd 1957; Cucin and Regier 1965; Spangler

1970). Further, the homing tendency of kokanee (Vernon 1957) and the genetically isolating mechanism of early fall and late fall spawning would contribute to the formation of several populations. Evidence collected to date suggests that kokanee planted as fingerlings in South Bay spawned in the Manitoulin area and did not mix with Georgian Bay kokanee.

Success of the introduction will ultimately be measured by the ability of kokanee to establish self-reproducing populations of a size that will supplement some angling and commercial fisheries of Lake Huron. If kokanee do not become abundant enough to support commercial or angling fisheries, or, if when abundant, they are too small, they may still serve as a valuable addition to the complex of forage fish, which has been reduced in recent years to only a few species.

Acknowledgments

The author acknowledges the contribution to this paper by personnel of the Ontario Department of Lands and Forests administrative districts bordering Lake Huron, commercial fishermen, and members of the public. Mrs E. Jermolajev, who analyzed stomach contents, made it possible to discuss food habits. Pesticide analyses were conducted by R. Frank of the Ontario Department of Agriculture and Food, Provincial Pesticide Residue Testing Laboratory, Guelph, Ont. The staff of the South Bay Fisheries Research Station provided advice and carried out much of the work under the direction of F. P. Maher and, more recently, C. A. Lewis. Special acknowledgment is made of the essential and enthusiastic support for the project by R. N. Johnston, former Chief of the Research Branch, and by K. H. Loftus, Section Supervisor, who coordinated the arrangements for egg supplies and provided encouragement when it was important. The manuscript was reviewed by K. H. Loftus and W. J. Christie.

ANONYMOUS. 1968. Lake Huron unit, p. 31–56. *In* Annual project report of Research Branch, Ontario Department of Lands and Forests, Fisheries Section. 1969. Great Lakes Fishery Commission, Annual Report for the year 1968. 69 p.

AVERETT, R. C. 1966. Studies of the ecology of kokanee in Odell Lake, Oregon. Oreg. State Game Comm. Res. Div. Rep. Fed. Aid Proj. F-71-R-2 Kokanee Res. 3: 20 p.

BERST, A. H., AND G. R. SPANGLER. 1970. Population dynamics of F_1 splake, (*Salvelinus fontinalis* × *S. namaycush*) in Lake Huron. J. Fish. Res. Bd. Canada 27: 1017–1032.

BERST, A. H., AND A. A. WAINIO. 1967. Lamprey parasitism of rainbow trout in Southern Georgian Bay. J. Fish. Res. Bd. Canada 24: 2539–2548.

BRUBACHER, M. J. 1970. Lake Huron committee report to the management and research committee. Great Lakes Fish. Comm. Annu. Meet., June 16–18, 1970.

BUDD, J. C. 1957. Movements of tagged whitefish in northern Lake Huron and Georgian Bay. Trans. Amer. Fish. Soc. 86: 128–134.

BUDD, J. C., AND F. E. J. FRY. 1960. Further observations on the survival of yearling lake trout planted in South Bay, Lake Huron. Can. Fish Cult. 26: 7–13.

BUSS, K. MS 1957. The kokanee. Pa. Fish. Comm. Spec. Purpose Rep. 12 p. (Mimeo.)

CHAPMAN, D. W., H. J. CAMPBELL, AND J. D. FORTUNE, JR. 1967. Salmonid distribution and food in Elk Lake, Oregon. Trans. Amer. Fish. Soc. 96: 308–312.

CHAPMAN, D. W., AND J. D. FORTUNE, JR. 1963. Ecology of kokanee salmon. Oregon State Game Comm. Res. Div. Rep. p. 11–42.

CLEMENS, W. A., D. S. RAWSON, AND J. L. MCHUGH. 1939. A biological survey of Okanogan Lake, British Columbia. Fish. Res. Board Can. Bull. 56: 70 p.

COBLE, D. W. 1967. The white sucker population of South Bay, Lake Huron, and the effects of sea lamprey on it. J. Fish. Res. Bd. Canada 24: 2117–2136.

COOPER, J. E. K. MS 1964. The bottom fauna of South Bay, Lake Huron. M.A. Thesis. Univ. of Toronto, Toronto, Ont. 166 p.

CUCIN, D., AND H. A. REGIER. 1965. Dynamics and exploitation of lake whitefish in southern Georgian Bay. J. Fish. Res. Bd. Canada 23: 221–274.

GERKING, D. 1967. The biological basis of freshwater fish production. Blackwell Scientific Publication, Oxford and Edinburgh. 495 p.

HORAK, D. L., AND H. A. TANNER. 1964. The use of vertical gill nets in studying fish depth distribution, Horsetooth Reservoir, Colorado. Trans. Amer. Fish. Soc. 93: 137–145.

LORZ, H. W., AND T. G. NORTHCOTE. 1965. Factors affecting stream location, and timing and intensity of entry by spawning kokanee (*Oncorhynchus nerka*), into an inlet of Nicola Lake, British Columbia. J. Fish. Res. Bd. Canada 22: 665–687.

MAHER, F. P. 1964. On the feasibility of introducing kokanee the land-locked sockeye salmon, *Oncorhynchus nerka* Kennerlyi to the Great Lakes. Ont. Dep. Lands Forests Sect. Rep. (Fish.) 55: 27 p.

MCCOMBIE, A. M. 1967. The thermal regime of South Bay, Manitoulin Island. J. Fish. Res. Bd. Canada 24: 101–125.

NELSON, J. S. 1968. Distribution and nomenclature of North American kokanee, *Oncorhynchus nerka*. J. Fish. Res. Bd. Canada 25: 409–414.

NORTHCOTE, T. G., AND H. W. LORZ. 1966. Seasonal and diel changes in food of adult kokanee (*Oncorhynchus nerka*) in Nicola Lake, British Columbia. J. Fish. Res. Bd. Canada 23: 1259–1263.

RECKAHN, J. A. 1970. Ecology of young lake whitefish (*Coregonus clupeaformis*) in South Bay, Manitoulin Island, Lake Huron, p. 437–460. *In* C. C. Lindsey and C. S. Woods [ed.] Biology of coregonid fishes. University of Manitoba Press, Winnipeg, Man.

RICKER, W. E. 1937. The food and the food supply of sockeye salmon (*Oncorhynchus nerka* Walbaum)

in Cultus Lake, British Columbia. J. Biol. Bd. Canada 3: 450–468.

1940. On the origin of kokanee, a freshwater type of sockeye salmon. Trans. Roy. Soc. Can. Ser. III, Sect. V, 34: 121–135.

ROBBINS, O., JR. 1966. Flathead Lake (Montana) fishery investigations 1961–1964. U.S. Bur. Sport Fish. Wildlife Tech. Pap. 4: 26 p.

SMITH, S. H. 1968. Species succession and fishery exploitation in the Great Lakes. J. Fish. Res. Bd. Canada 25: 667–693.

SPANGLER, G. R. 1970. Factors of mortality in an exploited population of whitefish, *Coregonus clupeaformis*, in northern Lake Huron, p. 515–529. *In* C. C. Lindsey and C. S. Woods [ed.] Biology of coregonid fishes. University of Manitoba Press, Winnipeg, Man.

VERNON, E. H. 1957. Morphometric comparison of three races of kokanee (*Oncorhynchus nerka*) within a large British Columbia lake. J. Fish. Res. Bd. Canada 14: 573–598.

WEBSTER, D. A., AND W. FLICK. 1960. Results of planting kokanee salmon in two Adirondack Mountain Lakes, New York. Progr. Fish-Cult. 22(2): 59–63.

Occurrence of the Bowhead or Greenland Right Whale (*Balaena mysticetus*) in Canadian Arctic Waters

A. W. MANSFIELD

Fisheries Research Board of Canada
Arctic Biological Station, Ste. Anne de Bellevue, Que.

MANSFIELD, A. W. 1971. Occurrence of the bowhead or Greenland right whale (*Balaena mysticetus*) in Canadian arctic waters. J. Fish. Res. Bd. Canada 28: 1873–1875.

The action taken in December 1970 by the U.S. Department of the Interior in placing eight species of large whales on an endangered species list has emphasized the need for up-to-date information on their populations. The present paper summarizes a large number of observations on one of these eight species and suggests that the bowhead population of Canada is recovering well after intensive exploitation up till the early years of the present century, though it may amount to only a small percentage of the population present before commercial whaling began.

MANSFIELD, A. W. 1971. Occurrence of the bowhead or Greenland right whale (*Balaena mysticetus*) in Canadian arctic waters. J. Fish. Res. Bd. Canada 28: 1873–1875.

Le geste du ministère américain de l'Intérieur, en décembre 1970, de placer huit espèces de grandes baleines sur la liste des espèces en danger de disparition fait ressortir le besoin de renseignements à la page sur les stocks. Le présent travail résume un grand nombre d'observations sur une des huit espèces. Nous croyons que la population canadienne de baleines franches du Groenland est en bonne voie de recouvrement après une exploitation intensive qui a duré jusqu'au début du siècle présent. Il se peut toutefois que cette population ne représente qu'un faible pourcentage de ce qu'elle était avant son exploitation commerciale.

Received July 20, 1971

IT is now 250 years since a fishery for arctic right whales began in the waters of eastern Canada and western Greenland. Like so many whaling ventures, it reached a peak of success and then declined quickly as the stock of whales became exhausted. From the beginning of the 20th century until quite recently, the right whale has been a rare mammal and few biologists have been fortunate enough to see one. It is not surprising, therefore, that our knowledge of the habits of this species is still based largely on the accurate observations recorded by the whaling captain William Scoresby in his history and description of the whale fishery (1820), and by Scammon in his account of the American whale fishery in the North Pacific (1874).

The species was known to British and American whalers by a variety of names: arctic right whale, Greenland right whale, Greenland whale, great polar whale, and bowhead. The last name, which was used by American whalers in the Bering Sea and the Arctic Ocean, is the most appropriate vernacular name and refers to the whale's most distinctive feature, the strongly arched upper jaws (Fig. 1).

Printed in Canada (J2246)

In the days of the sailing ship, right whales were the most sought after because of their slow speed and relative ease of capture. They were highly prized for their great yield of blubber, which had the advantage of keeping them afloat when killed, and the large amount of baleen that was very valuable at certain periods of the whale fisheries. The bowhead fishery was first attempted in Davis Strait and the waters to the north by the Dutch in 1719 (Fraser 1949). By the middle of the 19th century, whaling had become unimportant in this area, and it ceased altogether in 1913 when the last whaling ship left Dundee in Scotland (Lubbock 1955). The Bering Strait fishery began before the middle of the 19th century and was an American enterprise (Scammon 1874). Bowheads were hunted nearly to extinction and this fishery was also abandoned at the beginning of the 20th century. Now, under the rules of the International Whaling Commission, bowheads are completely protected from any commercial exploitation, though Eskimos are allowed to obtain them for food. About 10 are taken annually at Point Hope and Point Barrow in Alaska by Eskimos hunting them from skin boats or *umiaks*, but only two have been taken in the Canadian Arctic in recent years.

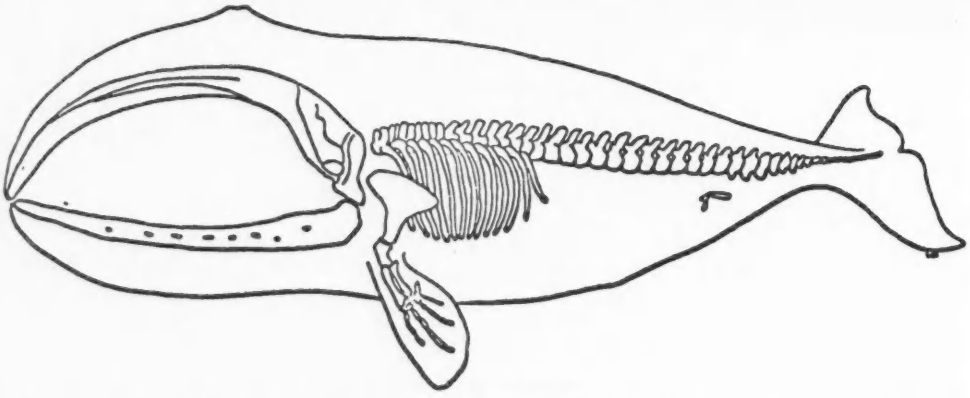

FIG. 1. Skeleton and body outline of the bowhead (after Eschricht and Reinhardt (1866) and Scammon (1874)).

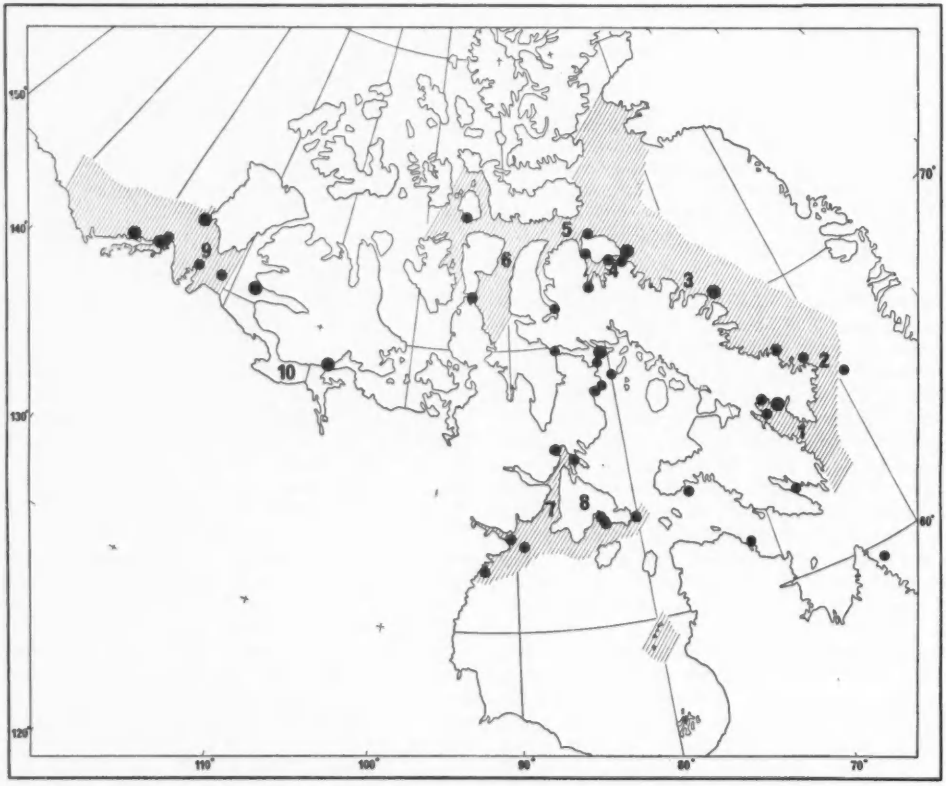

FIG. 2. Distribution of the bowhead in Canadian arctic waters. Shaded areas — former known whaling grounds (after Lubbock 1955; Townsend 1935); large black dots — more than 10 whales seen together, or more than 10 sightings in one season; small black dots — less than 10 whales seen together, or less than 10 sightings in one season. Numbers refer to the following place names mentioned in the text: (1) Cumberland Sound; (2) Cape Dyer; (3) Cape Eglinton; (4) Pond Inlet; (5) Lancaster Sound; (6) Prince Regent Inlet; (7) Roes Welcome Sound; (8) Southampton Island; (9) Amundsen Gulf; (10) Coronation Gulf.

Distribution

During the last 15 years numerous observations of bowheads have become available to the Fisheries Research Board, mostly through the Annual Game Reports submitted by arctic detachments of the Royal Canadian Mounted Police to their headquarters in Ottawa. Other observations have been received from ice observers and other personnel aboard government ships and aircraft, and from pilots of light aircraft. Detailed citations will be published in another paper, and only a general summary of the observations is given here.

Eastern Canadian Arctic

The observations from eastern arctic waters show a great similarity in distribution to former known whaling grounds (Fig. 2). These include (numbers in parentheses refer to Fig. 2): Cumberland Sound (1), the eastern coast of Baffin Island from Cape Dyer (2) to Cape Eglinton (3); Pond Inlet (4); Lancaster Sound (5); Prince Regent Inlet (6); Roes Welcome Sound (7); and southern Southampton Island (8) (Lubbock 1955). Though little is known of the movements of the bowhead in these areas, its former abundance at the edge of the fast ice in western Hudson Bay in the spring suggests that it may be a year-round resident, making only local movements dictated by the distribution of food and ice cover. It has not been possible to estimate total numbers, but herds of from 5 to 20 whales have been seen on several occasions, and up to 50 whales have been counted at one locality in a single season.

Western Canadian Arctic

Bowheads in the western arctic form part of a population that migrates through Bering Strait in the early spring. In April and May, they pass Point Hope in Alaska, where they are hunted by Eskimos at the edge of the fast ice. In 1960, 1961, and 1962, D. C. Foote (unpublished data) observed at least 127, 49, and 177 whales, respectively, pass by Point Hope. From here they continue past Point Barrow and make their way into Amundsen Gulf (9) and as far east as Coronation Gulf (10), where they occupy all the former known whaling grounds (Townsend 1935). At several localities in the western Canadian Arctic, herds of 20–30 bowheads have been seen, with as many as 100 individuals sighted in one season. The whole population apparently returns to the Bering Sea in the fall and spends the winter amongst the floating pack ice about the Aleutian and Kurile islands.

Observations suggest that the bowhead population of Canada is recovering well after intensive exploitation up till the early years of the present century, though it may amount to only a small percentage of the population present before commercial whale fisheries began.

Eschricht, D. F., and J. Reinhardt. 1866. On the Greenland right whale (*Balaena mysticetus* Linn.), p. 1–150. *In* W. H. Flower [ed.] Recent memoirs on the Cetacea. Ray Society, London.

Fraser, F. C. 1949. Whales and dolphins, p. 201–376. *In* J. R. Norman and F. C. Fraser [ed.] Field book of giant fishes, whales and dolphins. G. P. Putnam's Sons, New York, N.Y.

Lubbock, B. 1955. The arctic whalers. Brown, Son and Ferguson, Ltd., Glasgow, Scotland. 480 p.

Scammon, C. M. 1874. The marine mammals of the north-western coast of North America, described and illustrated, together with an account of the American whale-fishery. John H. Carmany and Co., San Francisco, California. (Reprinted 1968 by Dover Publications, New York, N.Y.)

Scoresby, W. 1820. An account of the arctic regions, with a history and description of the northern whale fishery. A. Constable and Co., Edinburgh.

Townsend, C. H. 1935. The distribution of certain whales as shown by logbook records of American whale ships. Zoologica 29: 1–50.

Accumulation and Persistence of DDT in a Lotic Ecosystem

J. B. DIMOND, A. S. GETCHELL, AND J. A. BLEASE

Departments of Entomology and Biochemistry
University of Maine, Orono, Me. 04473, USA

DIMOND, J. B., A. S. GETCHELL, AND J. A. BLEASE. 1971. Accumulation and persistence of DDT in a lotic ecosystem. J. Fish. Res. Bd. Canada 28: 1877–1882.

DDT persisted in streams of several small watersheds in Maine for at least 10 years following light applications to the forest. Residues declined sharply within 2 or 3 years after application, but after 10 years were still well above concentrations detected in untreated streams. This was true of all components studied: muds, plants, invertebrates, fish, and fish-eating birds. The prolonged persistence led to cumulative residue levels in streams sprayed more than once. Concentration of residues through the food chain was evident.

DIMOND, J. B., A. S. GETCHELL, AND J. A. BLEASE. 1971. Accumulation and persistence of DDT in a lotic ecosystem. J. Fish. Res. Bd. Canada 28: 1877–1882.

Dans les cours d'eau de plusieurs bassins peu étendus de l'Etat du Maine, le DDT a subsisté pendant au moins 10 ans après application légère aux forêts. Il y eut déclin marqué des résidus pendant les 2 ou 3 années qui suivirent l'application, mais après 10 ans, la teneur en était encore bien supérieure à celle des cours d'eau non traités. Ceci s'applique également aux autres constituants étudiés: vases, plantes, invertébrés, poissons et oiseaux ichthyophages. Cette contamination persistante est responsable de l'accumulation progressive des résidus dans les cours d'eau traités plus d'une fois. L'accumulation est évidente à tous les stades du cycle alimentaire.

Received May 4, 1971

THIS report describes the DDT residues detected in several components of a lotic ecosystem in Maine in the year of spray application, up to 10 years following single applications, and following one or two reapplications. The history of DDT treatment of the study area is precisely known, a feature often lacking in residue-monitoring studies.

DDT was applied at 1 lb/acre in 7 of the years between 1954 and 1967 for control of the spruce budworm, *Choristoneura fumiferana*, in northern Maine. The resulting mosaic of treatment histories covers 680,000 contiguous acres, of which 306,000 acres were treated once in different years, 204,000 acres twice, and 170,000 acres three times, the maximum. A map of the areas treated in the various applications was presented by Dimond and Sherburne (1969).

The area is well suited to studies of persistence, accumulation, and cycling of DDT in a largely natural environment. The present report covers persistence data for DDT and its metabolites in aquatic muds, plants, aquatic insects, fishes, and fish-eating birds.

Printed in Canada (J2158)

Methods

Areas selected for study involved small watersheds that received various numbers of application of DDT. These included brooks treated once in 1958, 1960, 1961, 1963, 1964, or 1967, as well as some treated in 2 or 3 of these years. Adjacent watersheds that were not treated served as controls. One to seven watersheds having each number of applications and 10 untreated watersheds were studied.

Collections were made in 1967 and 1968 of muds, plants, invertebrates, and fish, and in 1969 of birds. Samples were wrapped in aluminum foil and placed in plastic bags or held in stoppered glass bottles. They were frozen within a few hours of collection and held at –15 C up to several months until extraction of pesticides. Collection and residue-extraction techniques for the specific types of samples were as follows.

Stream muds were sampled in 43 streams by collecting and mixing 1-pint quantities from the bottoms of three successive pools moving upstream from the point of access, usually a road or trail. Since the streams varied in size and gradient, the samples varied in proportion of organic sediment.

DDT residues were extracted from muds as described earlier for terrestrial soils (Dimond et al. 1970). Since the samples were air-dried prior to extraction, it is difficult to compare the residues directly with those in or-

ganisms, where DDT level is expressed as ppm of wet weight. Possible losses of the residue from muds during the drying process were not determined.

Aquatic plants were collected in 49 streams over several hundred feet upstream from the point of access. Algae or higher plants or both were collected, depending upon what was present. Collecting continued until about 1 gal by volume was accumulated. For each stream and collection date, the entire plant mass was ground, mixed, and subsampled to provide the portion for analysis. Plant species were not identified. Extraction procedures for plants were as described for nonfatty foods by Mills et al. (1963).

Of the invertebrates, the most suitable for residue analysis, in terms of size and abundance, was the crayfish, *Cambarus bartoni*. Residue data on the extensive collections of these were reported earlier (Dimond et al. 1968). The remaining invertebrates, chiefly insects, were so small that it was difficult to obtain adequate samples of single species. Most were analysed as pools of 50 or more individuals of mixed species, both herbivores and carnivores. These smaller invertebrates were captured from riffles with Surber bottom samplers. Samples of sufficient size were obtained in 51 of 54 potential study streams. Freshwater mussels, which have been reported as useful indicators of pesticide residue levels, were collected in only five of the brooks studied, the larger, slower-flowing ones. They were analysed as pools of 10–15 individuals from each stream; shells were included in the analyses. Residues were extracted from all animals sampled in the manner discussed later.

The principal fish collected was the brook trout, *Salvelinus fontinulis*. It was common in 38 of the study streams and 480 were captured and analysed. Where trout were absent or uncommon, other species were taken. The other species most commonly collected was the creek chub. *Semotilus atromaculatus*. Several other species were too few in numbers to report results in this paper; however, residue levels appeared similar to those in trout and creek chubs. The fish were captured by angling. Where possible, at least 10 fish were collected from each stream.

Ten trout in five of the more substantial collections were analysed separately to assess variability in residue level within samples. Agreement among individuals within streams was rather close. Standard errors were 7–11% of mean residues in four treated streams and 40% in an untreated sample. Using an equation for calculating a sample size (Snedecor and Cochran 1967) that would produce residue estimates with a 5% risk that the error would exceed 10% of the mean residue level, sample sizes of 16–44 fish were determined for the groups with lower standard errors. Similar calculation for the untreated stream was 152 fish. Lowering precision to 20% of the mean residue and recalculating produced required sample sizes of 5–11 and 38 fish, respectively, for treated and untreated streams. The remaining collections of fish were analysed as pools segregated by species. Each pool was homogenized in a food mill, with a 10-g subsample analysed. Since the pools contained 5–15 individuals, most results can be expected to fall within the lower precision level discussed above.

The species of birds taken purposively were kingfishers, *Megaceryle alcyon*, and common mergansers, *Mergus merganser;* however, two hooded mergansers, *Lophodytes cucullatus*, from one family group were inadvertently taken. All but one common merganser and one hooded merganser were young-of-the-year. Kingfishers were not classed by age. Collections with shotguns were largely made in late July and August, when the young approached adult size. Two exceptions to this, collected early, are discussed separately. In most cases where a bird was shot, a special collection of fish was also made. This was desirable since the birds were mostly collected on different, larger streams than the other system components, making a direct comparison between residues in the birds and lower trophic levels difficult. Gut contents of recently fed birds were saved as well for separate residue analysis. Totals of 15 mergansers and 10 kingfishers were collected.

Each bird was handled individually during residue analysis. Because of their size, each was homogenized in a food mill after plucking, and a 10-g subsample extracted. Separate analysis of plumage showed much lower residue levels than the corresponding carcasses; however, the minute contribution of plumage to the total weight of the bird made it pointless to correct the results downwards.

In several instances, more than one bird from a family were collected. Since variability in residues within families was much less than between families in areas of similar treatment, the family means were used to compare with values for single birds.

Extraction of all animal samples was accomplished with a modification of the procedure for nonfatty foods (Mills et al. 1963) designed to cope with the increased fat of whole animal samples. Subsample size was reduced to 25 g or less, with cleanup on partially deactivated (5% added H_2O) Florisil and 20% dichloromethane in petroleum ether.

Gas chromatographic apparatus and techniques, and laboratory controls have been described in the earlier publications in this series (Dimond et al. 1970, 1968; Dimond and Sherburne 1969). Recoveries of added quantities of DDT in the various sample types routinely averaged 85%. The reported residues, which are not corrected for this, must be considered as conservative.

A number of additional laboratory controls should be mentioned. On several occasions, two or more successive subsamples from single birds and pooled-fish homogenates were analysed. Differences seldom exceeded 10% of the total residue, suggesting that mixing of the homogenates was adequate. Two similar homogenates, in this case of landlocked salmon, were prepared and duplicate subsamples analysed by us and by the Wisconsin Alumni Research Foundation. Our results exceeded those of WARF by 3 and 25%. It is impossible to determine how much of the difference was due to analytical methods and how much to true differences in the duplicate subsamples. In any case, errors of even 25% would not change the conclusions drawn from this study.

Several samples were reextracted two or three times. Residues detected in the second extraction averaged

6% of the total of the first extraction. Data are not corrected for this. Third extractions usually produced values below the level of detectability, .01 ppm.

Evaluation of interference of polychlorinated biphenyls with detection of DDT residues (Reynolds 1969; Risebrough et al. 1969) was not made. The lack of unexplained peaks on chromatograms suggested no significant contamination with these materials or with insecticides other than DDT. In addition, the excellent agreement between the known spray history and recovery of DDT in samples ruled out other environmental contaminants as significant factors.

Results

A single application of DDT produced rather high initial levels of residue in all stream components studied (Table 1). Following a single application, residues dropped rapidly for the first year or two, but further reduction in residue was sometimes difficult to demonstrate. Even 10 years after application, residues were still well above those in brooks never treated. This led to cumulative levels of DDT in samples from streams treated two and three times. These results were apparent in the stream components collected abundantly and suggested in those more difficult to sample, mussels and birds.

One apparent discrepancy in the data is seen in comparing residues in streams sprayed twice with those sprayed three times, the latter sometimes averaging less contamination than the former. This arose because many of the twice-sprayed streams were treated recently, e.g., in 1967, whereas all thrice-sprayed streams were treated no more recently than 1964.

The within-treatment variability of residue results was very great (Table 1). This could arise from a

TABLE 1. Mean total residues and ranges (ppm) of DDT and metabolites in various components of a lotic ecosystem having different treatment histories.

Years after one application	Muds[a]	Plants	Insects	Mussels	Trout	Chubs	Kingfishers	Mergansers
0(7)[b]	.83 (.04–1.6)	.74*[c] (.22–.90)	2.41* (.4–6.4)	.20 (.19–.21)	8.21* (3.2–15.3)	9.84	–	–
1(4)	1.08 (.25–1.9)	.06 (.03–.09)	–	–	3.51** (2.4–4.9)	5.46	–	–
2(1)	–	–	.33	.06	–	–	9.44	–
3(2)	.21 (.12–.30)	–	.21	–	2.10	1.55	–	–
4(7)	.21 (.16–.25)	.02 (.01–.02)	.28 (.05–.7)	–	.99 (.63–1.4)	1.34	–	–
5(5)	.59 (.07–1.9)	.04 (.01–.13)	.43 (0–.6)	.03	.79 (.74–.84)	.76	–	–
6(3)	.06	.01	.06	–	.68 (.27–1.1)	–	4.21 (3.8–4.6)	–
7(5)	.21 (.11–.31)	.05 (0–.09)	.22 (.12–.43)	–	.36 (.32–.39)	–	–	–
8(2)	.13	–	.27 (.19–.34)	–	.27 (.23–.32)	.21	–	–
9(4)	.03 (.02–.04)	.01 (.01–.02)	.44 (.06–1.1)	–	.44 (.23–.66)	–	–	–
10(4)	.07 (0–.16)	.02	.27	–	.35 (.23–.60)	.36	–	–
Never sprayed (10)	.006* (0–.02)	.007 (0–.01)	.05* (0–.12)	.01	.07* (.04–.1)	.04*	.39* (.30–.5)	.97* (.54–1.6)
Two sprays (7)	.43 (.17–.77)	.09 (.02–.24)	.33 (.17–.87)	–	2.92** (1.0–7.9)	1.55	6.82	8.17 (3.8–13.5)
Three sprays (7)	.35 (.17–.6)	.09 (.05–.1)	.58 (.15–1.3)	–	2.11 (1.1–3.7)	3.48	10.06 (9.5–10.6)	–

[a]Values on basis of dry weight; all others, wet weight (total body).

[b]Number of streams available for sampling. Samples of some components, e.g., mussels, birds, were not collected in all streams.

[c]*Significantly different ($P = 0.05$) from all other values; **significantly different ($P = 0.05$) from all other values except those similarly marked.

number of sources, e.g., differences in meteorological conditions, and therefore settling of spray, when different watersheds were treated, differences in water chemistry, and (Table 2) differing watershed sizes.

As in many residue studies, DDE was the principal component of the residue in animal samples analysed. It comprised 60–85% of the total residue in animals, the remainder being about equally divided between *p,p'*-DDT and *p,p'*-DDD. Trace amounts of *o,p'*-DDT were occasionally seen. Apparent degradation of DDT was much less in muds and plants. Percentages averaged 35, 45, and 20, respectively, for *p,p'*-DDT, -DDE, and -DDD. The *o,p'*-DDT isomer was commonly found in plant samples in a spray year but not in subsequent years.

The special data obtained on the relation between residue levels in fish and those in fish-eating birds (Table 3) indicate that the mean increase in residue in birds over that in their food was 13 times. In comparison, the increase in residue from levels in plants to those in insects (Table 1) ranged between three and 12 times, averaging six. The increase from insects to trout appeared of the same order in cases of higher residue level but with little or no difference between the two levels where lower contamination existed. This anomaly was not explained. Total concentration from plants to birds in this system, therefore, remains questionable, but apparently varies between 70 and 450 times, the greater concentration occurring where there is greater total contamination.

Two common mergansers that were collected and analysed are not listed in Tables 1 or 3. Their residues were much higher than those in the other birds and may have been derived from contamination in the wintering areas. One of these, an adult female, was found dead in early June in an area with no spray history. Living mergansers at the time were courting. This bird contained 115 ppm of DDT and metabolites, as well as some unidentified materials. The residue was evidently derived elsewhere, and may have contributed to the death of the bird following the stress of migration and courtship. The second bird was a recently hatched juvenile, collected in mid-June, from an area never sprayed. It weighed only 45 g and bore entirely juvenile plumage. Further collection of mergansers was delayed a month so that all subsequent samples approached or equalled adults in size, plumage, and flight capability. This bird contained 46 ppm of residue, presumably derived in this case from the mother through the egg, the mother again carrying contamination from farther south. Among migratory birds, several weeks of residence are apparently required, as in robins (Dimond et al. 1970), before the individuals reflect the contamination of the summer habitat. It is perhaps suggestive that the second bird was one of only three hatchlings in the family involved; Kortright (1953) states that clutch size in the common merganser is 6–17 eggs and usually 9–12.

TABLE 2. Residue levels of DDT in muds from streams in watersheds of various sizes.

Stream	Residue (*ppm*)	Acres
1 yr after spray		
Beaver Pond Br.	1.912	4000
Jack Aiken Br.	1.081	4000
Smith Br.	.248	1500
5 yr after spray		
Blackwater R.	1.958	21000
Burntland Str.	.151	5200
Presque Isle Str.	.286	3700
Houlton Br.	.073	1900
Grendell Br.	.072	900

TABLE 3. Residues of DDT (ppm of fresh weight) in individual mergansers or kingfishers, their gut contents, and fish samples collected simultaneously in the same watersheds. Concentration ratios of residue are also presented.

Residue (*ppm*)			Ratio	
Bird	Gut contents	Fish	Bird/gut contents	Bird/fish
3.841		.416		9.23
9.442	.999	.732	9.45	12.87
8.018		.476		16.84
6.413		.447		14.34
10.061	1.145	.870	8.78	11.56
.585		.045		13.00
.414	.046		9.00	
3.808	.338		11.26	
6.821	.245		27.84	

Discussion

The results of this work corroborate the persistent tendencies of DDT to spread and concentrate widely in food chains, as reported by many others, and in the present study one can link persistent residue levels to known spray inputs. The continued contamination of probably all lotic organisms

through 10 years following a single application is in itself disturbing. But the important question posed is whether ecological damage results from the residue levels detected in this study. The acute effects in the year of spray are known; some aquatic invertebrates and fish are killed (Dimond 1967; Warner and Fenderson 1962).

The levels found in fish-eating birds in this study appear sublethal; however, reproductive effects through enzyme induction remain a possibility. In laboratory studies, eggshell thinning was induced in kestrels (Wiemeyer and Porter 1970) and mallard ducks (Heath et al. 1969) fed diets containing 2.8 ppm (wet weight) of DDE. The fish examined in streams treated once in this study approached or exceeded these levels of DDT for only 2 or 3 years after application. Fish, however, from some brooks sprayed three times maintained these levels for several years after the last application. In a field study, Ames (1966) found fish eaten by a declining osprey population to contain between 1 and 5 ppm of DDT residues.

The residues found in mergansers and kingfishers, predators of smaller fish, may not be indicative of residues to be expected in the larger fish-eating birds, ospreys, and eagles. The principal prey of the latter birds might be sufficiently large as to involve an additional step in the food chain, with residues several times greater.

Residues found in streams in this study may also be considerably lower at all trophic levels than in ponds, which might serve as "sinks" for the surrounding watersheds. Present data for ponds are limited; however, residues in trout in two small ponds sampled during this study were three times greater than in small streams with the same number of applications of DDT (unpublished data).

Therefore, although the present study cannot demonstrate a harmful specific effect on fish-eating birds from the DDT applications involved, questions are raised that invite further study.

Burdick et al. (1964) noted high mortality of fry of lake trout that contained 3–4 ppm of DDT. Hopkins et al. (1969) reported lower levels of egg death and fry stunting in rainbow trout, critical residues in the fry and in the parent being between 1 and 2 ppm. Anderson and Everhart (1966), studying landlocked salmon, found that concentrations of DDT in ripe eggs were similar to those in the parent female. If the same relation holds for brook trout as for these other salmonids, their spawn may contain biologically significant levels of DDT for 3–4 years following a single application of DDT at 1 lb/acre and for several years following multiple applications.

The distribution of metabolites of DDT in lotic muds varies considerably from that reported (Dimond et al. 1970; Yule 1970) in surrounding terrestrial soils. The *p,p'* and *o,p'* isomers of DDT comprise the bulk of residue in the latter, with relatively small quantities of DDE and only traces of DDD. Brown and Brown (1970) and Yule and Tomlin (1971) reported similar relations between residues in terrestrial and aquatic soils. The greater degradation in stream muds may relate to the reportedly greater conversion abilities of anaerobic microorganisms (Wedemeyer 1966).

Acknowledgments

This work was supported by grant EP-00803 of the Environmental Protection Agency and by the Maine Life Sciences and Agriculture Experiment Station.

AMES, P. L. 1966. DDT residues in the eggs of the osprey in the northeastern United States and their relation to nesting success, p. 87–97. *In* N. W. Moore [ed.] Pesticides in the environment and their effects on wildlife. J. Appl. Ecol. Suppl. to Vol. 3.

ANDERSON, R. B., AND W. H. EVERHART. 1966. Concentration of DDT in land-locked salmon (*Salmo salar*) at Sebago Lake, Maine. Trans. Amer. Fish. Soc. 95: 160–164.

BROWN, N. J., AND A. W. A. BROWN. 1970. Biological fate of DDT in a subarctic environment. J. Wildlife Manage. 34: 929–940.

BURDICK, G. E., E. J. HARRIS, H. J. DEAN, T. M. WALKER, J. SHEA, AND D. COLBY. 1964. The accumulation of DDT in lake trout and the effect on reproduction. Trans. Amer. Fish. Soc. 95: 160–164.

DIMOND, J. B. 1967. Pesticides and stream insects. Maine For. Ser. Conserv. Found. Bull. 23: 21 p.

DIMOND, J. B., G. Y. BELYEA, R. E. KADUNCE, A. S. GETCHELL, AND J. A. BLEASE. 1970. DDT residues in robins and earthworms associated with contaminated forest soils. Can. Entomol. 102: 1122–1130.

DIMOND, J. B., R. E. KADUNCE, A. S. GETCHELL, AND J. A. BLEASE. 1968. Persistence of DDT in crayfish in a natural environment. Ecology 49: 759–762.

DIMOND, J. B., AND J. A. SHERBURNE. 1969. Persistence of DDT in wild populations of small mammals. Nature 221: 486–487.

HEATH, R. G., J. W. SPANN, AND J. F. KREITZER. 1969. Marked DDE impairment of mallard reproduction in controlled studies. Nature 224: 47–48.

HOPKINS, C. L., S. R. B. SOLBY, AND A. R. RITCHIE. 1969. DDT in trout and its possible effect on reproductive potential. N.Z. J. Mar. Freshwater Res. 3: 220–229.

KORTRIGHT, F. H. 1953. The ducks, geese and swans of North America. Wildlife Management Inst., Washington, D.C. 476 p.

MILLS, P. A., J. H. ONLEY, AND R. A. GAITHER. 1963. Rapid method for chlorinated pesticide residues in nonfatty food. J. Ass. Offic. Agr. Chem. 48: 186.

REYNOLDS, L. M. 1969. Polychlorobiphenyls (PCB's) and their interference with pesticide residue analysis. Bull. Environ. Contam. Toxicol. 4: 128–143.

RISEBROUGH, R. W., P. REICHE, AND H. S. ALCUTT. 1969. Current progress in the determination of the polychlorinated biphenyls. Bull. Environ. Contam. Toxicol. 4: 192–201.

SNEDECOR, G. W., AND W. C. COCHRAN. 1967. Statistical methods. 6th. ed. Iowa State Univ. Press, Ames, Iowa. 593 p.

WARNER, K., AND O. C. FENDERSON. 1962. Effects of DDT spraying for forest insects on Maine trout streams. J. Wildlife Manage. 26: 86–93.

WEDEMEYER, G. 1966. Dechlorination of DDT by *Aerobacter aerogenes*. Science 152: 647.

WIEMEYER, S. N., AND R. D. Porter. 1970. DDE thins eggshells of captive American kestrels. Nature 227: 737–738.

YULE, W. N. 1970. DDT residues in forest soils. Bull. Environ. Contam. Toxicol. 5: 139–144.

YULE, W. N., AND A. D. TOMLIN. 1970. DDT in forest streams. Bull. Environ. Contam. Toxicol. 5: 479–488.

Physical and Chemical Limnology of the Lakes of Manitoulin Island

H. H. HARVEY AND J. F. COOMBS

Department of Zoology
University of Toronto, Toronto, Ont.

HARVEY, H. H., AND J. F. COOMBS. 1971. Physical and chemical limnology of the lakes of Manitoulin Island. J. Fish. Res. Bd. Canada 28: 1883–1897.

Of 51 of the large lakes on Manitoulin Island investigated from 1965 to 1970, 10 were found to be dimictic and 41 polymictic, most of the latter being very shallow. Twenty of the polymictic lakes evidenced one or more trenches in the lake bottom. These trenches may be maintained by wind-induced water currents. In one such trenched lake, Smoky Hollow Lake, winter oxygen declined to less than 1 ppm before surface melt-water entered the lake under the ice sheet. Winter kills of fish such as yellow perch (*Perca flavescens*) and northern pike (*Esox lucius*) were observed in three lakes, but the presence of older age-classes of fish in most lakes suggested that extensive winter kills are not common. The survival of fishes in the many shallow lakes is made possible by the continued presence of at least a small amount of oxygen in winter and the timely arrival of surface melt-water under the ice sheet. Most of the lakes had a high *p*H (7.9–9.1) and were rich in magnesium (mean 17.9 ppm) in relation to calcium (34.2 ppm), consistent with the underlying dolomitic bedrock. Sodium (mean 1.5 ppm) and potassium (0.8 ppm) were present at unusually low concentrations.

HARVEY, H. H., AND J. F. COOMBS. 1971. Physical and chemical limnology of the lakes of Manitoulin Island. J. Fish. Res. Bd. Canada 28: 1883–1897.

Sur un total de 51 grands lacs de l'île Manitoulin étudiés de 1965 à 1970, 10 sont dimictiques et 41 polymictiques, la plupart de ces derniers, très peu profonds. Parmi les lacs polymictiques, 20 ont une ou plusieurs tranchées sur le fond, probablement formées par les courants de dérive. Dans un de ceux-ci, le lac Smoky Hollow, la teneur hivernale en oxygène a baissé à moins de 1 ppm avant que l'eau superficielle provenant de la fonte des neiges n'ait pénétré dans le lac sous la couche de glace. Il s'est produit dans trois lacs des mortalités hivernales d'espèces telles que la perchaude (*Perca flavescens*) et le grand brochet (*Esox lucius*). Toutefois, la présence de vieilles classes d'âge dans la plupart des lacs donne à entendre que les mortalités hivernales ne sont pas très communes. La présence d'une quantité minimale constante d'oxygène et l'arrivée opportune des eaux de fonte sous la couche de glace assurent la survie des poissons dans beaucoup de lacs peu profonds. La plupart des lacs ont un *p*H élevé (7.9–9.1) et sont riches en Mg (17.9 ppm en moyenne) par rapport au Ca (34.2 ppm), ce qui est compatible avec la nature dolomitique du substrat rocheux. La teneur en Na (1.5 ppm en moyenne) et en K (0.8 ppm) est exceptionnellement faible.

Received June 16, 1971

THIS paper reports a study of the regional limnology of the lakes of Manitoulin Island. During the period 1965–70, limnological measurements were made on 48 of the 70 island lakes greater than 0.5 km in length, including all those accessible overland, and 3 lakes slightly less than 0.5 km. Measurements included the physical features of lake basin, temperature, transparency, colour, and such chemical characteristics as oxygen, *p*H, dissolved solids, and principal ions. The resulting data were analysed with a view to: (1) defining the physical and chemical characteristics of a group of lakes lying within a large mass of dolomite; (2) providing an explanation for the presence of trenches in many of the lake basins; (3) finding an explanation for the survival of fishes in the many shallow lakes; and (4) establishing the environmental basis for subsequent analysis of the zoogeography of the fishes and zooplankton of the island lakes, which were isolated relatively recently from the Great Lakes.

Manitoulin Island (Fig. 1), the largest freshwater island in the world, has a length of 134 km and an area of 4113 km^2 (Chapman and Putnam 1966). The bedrock is Silurian dolomite in the southern three-quarters of the island, and Ordovician shales and limestones in the north. This bedrock is close to the surface and has been washed clean in many areas. The mass of the island rises steeply out of

Printed in Canada (J1824)

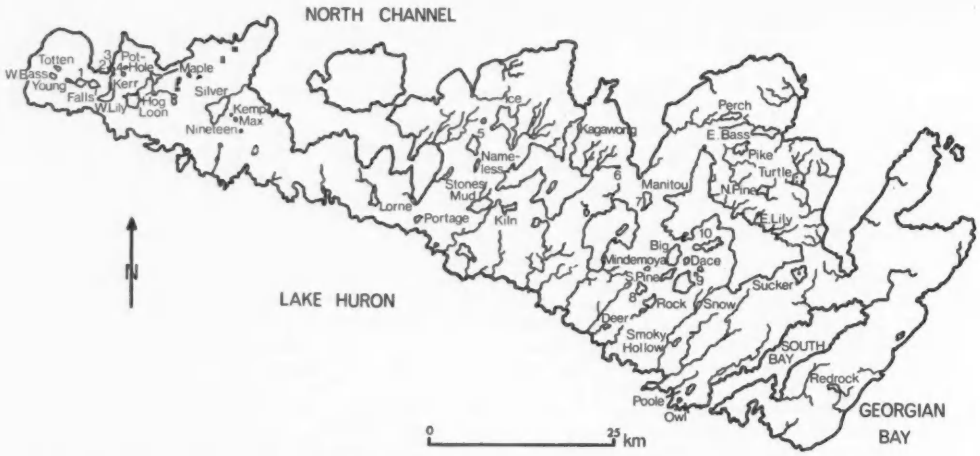

FIG. 1. Locations and drainages of the lakes of Manitoulin Island. 1, Wickett; 2, Linda; 3, Jenny; 4, Burnett; 5, Tobacco; 6, Sagigonsing; 7, Whitefish; 8, Martin; 9, Windfall; 10, Long.

the North Channel in the north and dips gently into Huron Lake in the south. In all, there are about 200 bodies of water on the island, but the three large lakes, Manitou, Kagawong, and Mindemoya, have a combined area of 197.2 km^2 and comprise 75% of the lake-surface area of the island. Of the 51 lakes studied, 13 occupy major rifts or gouges in the bedrock and 38 lie in shallow depressions in the overlying sediments. Many of the bedrock basins may be of glacial-erosion origin, Type 28d of Hutchinson (1957).

Methods

Contour maps for all lakes were prepared from topographic maps or aerial photographs and echo-sounder transects made with a Smith Inshore Graphic or RCA NJA-150. Temperatures in vertical sections were measured with an Applied Research Associates thermistor thermometer. Oxygen was determined by the azide modification of the Winkler method on 2–12 samples, depending on the depth of the lake. Transparency was measured by Secchi disk. Total dissolved solids and *p*H were determined in the field with an Electronic Switch Gear model MC3 and a Beckman 180 or Sargent PBL *p*H meter. Water samples were taken from 40 lakes for laboratory analysis of the constituents listed in Table 3. Additional analyses were conducted as follows: nitrogen as ammonia, Kjeldahl nitrogen, nitrite, and nitrate on 5 lakes, total and soluble phosphate on 6 lakes, chloride on 11 lakes, and iron on 31 lakes.

In Smoky Hollow Lake, oxygen and temperature were measured monthly at 14 stations and temperature recorded continuously at one station. In the study of sediment oxygen, samples were drawn with the KB corer (Brinkhurst et al. 1969), subsamples were centrifuged under oil, and gas analyses were performed on the supernatant liquid with a modification of the Scholander method (Harvey 1961).

The lakes were classed by frequency of circulation as dimictic (second-class lakes of Hutchinson 1957) or polymictic (third-class lakes) (Fig. 2). The polymictic lakes were classed as with or without trenches, and as shallow or deep. A trench was a depression with a slope of 4% or more and with an area of less than 25% of the lake surface. As visual observations indicated that wind action resuspended and redeposited bottom sediments through wave action, to a depth of 1–2 m, lakes with a maximum depth of more than 2 m except in trenches were arbitrarily classed as deep; in the trenched lakes only a small portion of the bottom area was trench (Table 1).

Physical Characteristics

TRENCHES

The outstanding physical feature of the lakes of Manitoulin Island was the presence of one or more trenches in the basins of many. Trenches occurred in half of the polymictic lakes (Fig. 2), most commonly along the southern margins, close inshore (Fig. 3). Commonly, these trenches were narrow, approximately 25–100 m wide, 200–300 m long, and 2–5 m deep in the shallow and 4–15 m in the deep lakes. The 16 shallow trenched lakes showed slopes ranging from 4 to 36% and the area of the trenches ranged from 1 to 23% of the lake-surface area (Table 1).

In the shallow lakes, wind-induced water currents may have produced and maintained the trenches. The north shore of Huron Lake is a re-

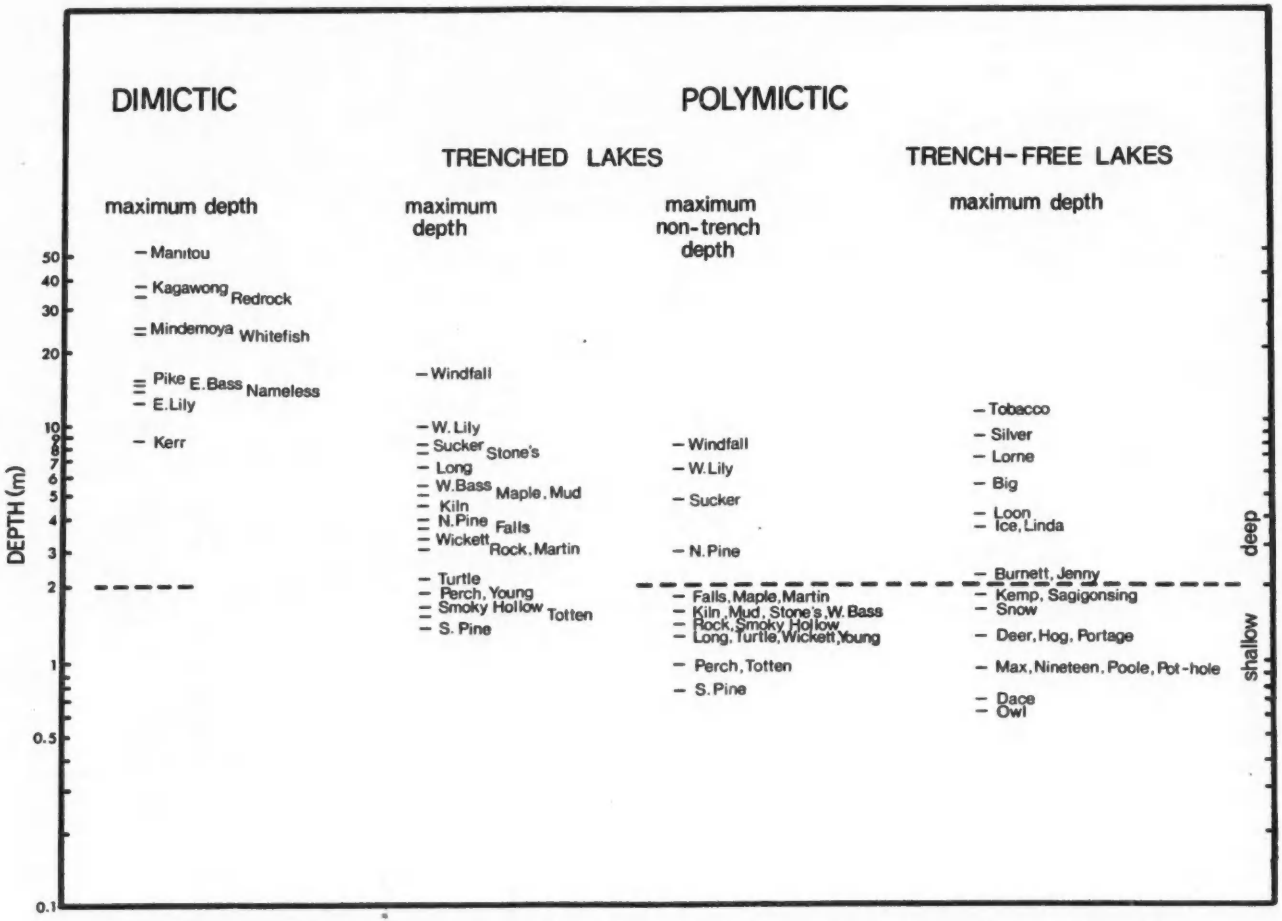

FIG. 2. Maximum depths of the several classes of lakes. In classifying lakes as shallow or deep, trenches were disregarded.

TABLE 1. Slopes and areas of trenches in the shallow and deep lakes.

Lake	Slope (%)		Max trench-free depth (*m*)	Trench area (% *of total*)
	Lakeward	Shoreward		
		Shallow lakes		
Turtle	4	20	1.2	1
Perch	1	6	0.9	7
Long	9	19	1.2	4
Smoky Hollow	6	6	1.4	7
South Pine	2	4	0.8	8
Rock	2	5	1.4	13
Martin	1	5	1.8	3
Kiln	10	11	1.5	1
Mud	14	13	1.5	2
Stone's	9	16	1.5	23
Maple	12	20	1.8	3
Falls	10	25	1.8	13
Wickett	6	13	1.2	4
Young	3	17	1.2	6
Totten	2	8	0.9	6
West Bass	24	36	1.5	1
Mean	7.2	14	1.4	6.4
		Deep lakes		
Sucker	6	10	4.6	6
North Pine	3	6	2.8	12
Windfall	3	7	7.6	9
West Lily	6	13	6.1	4
Mean	4.5	9	5.3	7.8

latively windy area, with summer winds predominantly from the northwest. Dye studies conducted along the trenches during windy periods revealed water currents close to the bottom and moving both along and across the trenches. Water velocities of up to 10 cm per sec were recorded during periods of moderate winds. In all the shallow lakes studied, the bottom sediments were soft and flocculent, but in the trenches there was often coarser material free of flocculent ooze. These differences support the hypothesis that the shallow-lake trenches were prevented from filling with sediment by the movement of deep water on the windward (downwind) side of the lake. In laboratory studies, water velocities of 9 cm per sec moved sand particles up to 2.5 mm in size (Kinsman 1965). Other reports (Francis 1953; Van Dorn 1953), however, have tended to minimize the stress on the bottom of a shallow water mass due to return water currents.

There was evidence that at least some of the trenches were dynamic rather than static features of the lake bottoms. In Smoky Hollow Lake 10–30 cm of soft sediment was deposited on the inshore edge of the trench on the northeast side of the lake (station 12) during the period 1968–70. Concurrently, the trench on the east side of South Pine Lake shifted southward some 50 m.

Biologically, the trenches in the shallow lakes may have considerable significance. With a winter ice cover of 63–70 cm, little or no water remained in the shallower portions of these lakes, and in some areas the thin layer of water beneath the ice became devoid of oxygen during winter stagnation. The small trenches appeared to provide winter refuges for some aquatic organisms, especially the larger fishes. For example, large net catches of yellow perch (*Perca flavescens*) and northern pike (*Esox lucius*) were taken in the trenches when a layer of ice covered Smoky Hollow Lake.

MORPHOMETRY

Maximum depth for the 51 lakes ranged from 0.6 to 50 m with 31 lakes less than 5 m, 9 between 5 and 10 m, and 11 lakes deeper than 10 m (Table 2). Mean depth ranged from 0.4 to 16 m, with 42

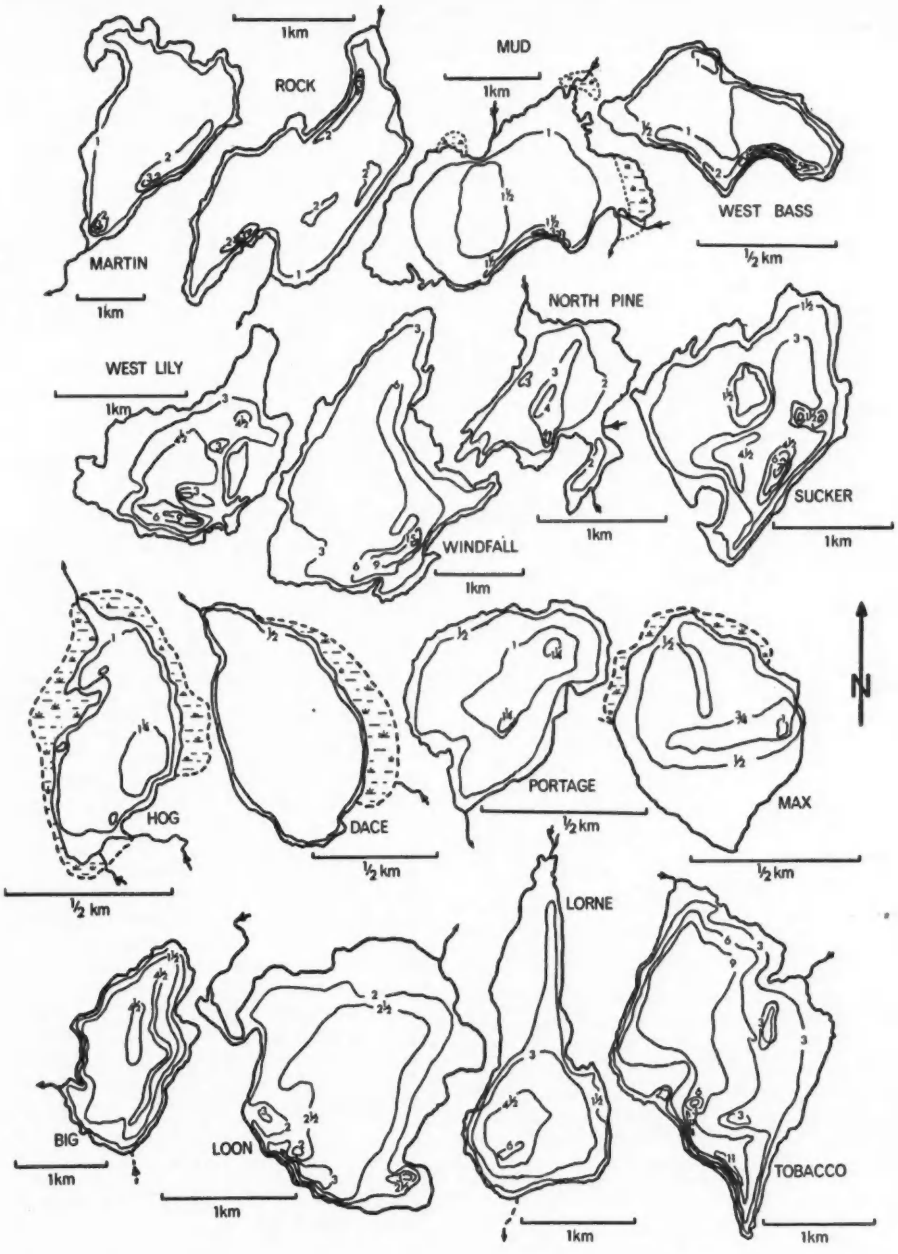

FIG. 3. Morphometry of 16 selected polymictic lakes. Top row: shallow trenched lakes; second row: deep trenched lakes; third row: shallow trench-free lakes; bottom row: deep trench-free lakes.

TABLE 2. Morphometric data for the 51 lakes studied.

Lake	Area (*ha*)	Vol ($m^3 \times 10^6$)	Depth			
			Max (*m*)	Mean (*m*)	Mean/max	Secchi (*m*)
Dimictic						
Redrock	54.6	4.11	32.0	7.5	0.24	8.8
Manitou	10311.1	1643.51	50.0	16.0	0.32	7.0
East Bass	274.0	15.72	13.4	5.7	0.41	2.5
East Lily	15.0	0.59	11.6	3.9	0.34	3.9
Pike	229.2	11.87	13.7	5.2	0.38	2.4
Whitefish	114.0	11.91	22.6	10.5	0.46	8.1
Mindemoya	3848.9	314.90	22.9	8.1	0.36	3.0
Kagawong	5555.7	563.46	33.9	10.2	0.30	7.9
Nameless	72.0	5.84	12.8	8.1	0.63	9.2
Kerr	17.6	0.30	7.9	1.7	0.22	4.2
Mean	2049.2	257.22	22.1	7.7	0.37	5.7
Polymictic						
Trenched, shallow						
Turtle	93.0	0.57	2.1	0.6	0.29	>2.1
Perch	194.3	1.48	1.8	0.8	0.42	>1.8
Long	324.1	3.05	6.1	1.0	0.16	3.5
Smoky Hollow	31.1	0.25	1.7	0.8	0.49	>1.7
South Pine	106.7	0.41	1.4	0.4	0.29	>1.4
Rock	145.0	1.28	2.8	0.9	0.32	>2.8
Martin	101.0	1.33	2.8	1.3	0.48	>2.8
Kiln	159.5	1.01	4.3	0.6	0.15	2.1
Mud	344.5	1.51	4.6	0.4	0.10	2.9
Stone's	60.1	0.90	7.0	1.5	0.21	4.9
Maple	58.5	0.68	4.6	1.2	0.25	3.0
Falls	101.0	0.89	3.4	0.9	0.27	>3.4
Wickett	97.5	0.99	3.1	1.0	0.34	>3.1
Young	9.4	0.09	1.8	1.0	0.52	>1.8
Totten	28.5	0.18	1.5	0.6	0.41	>1.5
West Bass	20.7	0.25	5.2	1.2	0.23	5.3
Mean	117.2	0.93	3.4	0.9	0.31	3.6[a]
Trenched, deep						
Sucker	232.3	5.08	7.6	2.2	0.29	4.8
North Pine	101.8	1.49	3.7	1.5	0.40	3.0
Windfall	466.2	15.04	15.3	3.2	0.26	8.0
West Lily	209.8	5.23	9.2	2.5	0.27	4.6
Mean	252.5	6.71	9.0	2.4	0.31	5.1
Trench-free, shallow						
Poole	58.0	0.26	0.9	0.5	0.49	>0.9
Snow	24.9	0.11	1.7	0.4	0.26	>1.7
Dace	54.4	0.27	0.7	0.5	0.65	>0.7
Owl	8.8	0.04	0.6	0.4	0.71	>0.6
Deer	28.5	0.14	1.2	0.5	0.40	>1.2
Sagigonsing	9.0	0.85	1.8	1.0	0.52	>1.8
Portage	35.7	0.23	1.2	0.7	0.53	>1.2
Nineteen	10.3	0.05	0.9	0.5	0.57	>0.9
Max	23.3	0.10	0.9	0.5	0.49	>0.9
Kemp	5.4	0.06	1.8	1.1	0.62	>1.8
Hog	19.3	0.18	1.2	0.9	0.74	>1.2
Pot-Hole	10.3	0.08	0.9	0.8	0.89	>0.9
Mean	24.0	0.20	1.2	0.7	0.57	

(*Continued*)

TABLE 2. Morphometric data for the 51 lakes studied. — (*Concluded*)

Lake	Area (*ha*)	Vol ($m^3 \times 10^6$)	Depth			
			Max (*m*)	Mean (*m*)	Mean/max	Secchi (*m*)
		Trench-free, deep				
Big	388.5	11.59	5.2	3.0	0.57	>5.2
Ice	730.4	7.63	3.7	1.1	0.29	>3.7
Tobacco	274.6	16.19	11.0	5.9	0.54	7.0
Lorne	131.0	3.01	6.7	2.3	0.34	2.7
Silver	532.3	12.45	8.5	2.4	0.28	>3.0
Loon	241.0	4.43	4.0	1.7	0.45	>4.0
Burnett	33.9	0.39	2.1	1.2	0.54	>2.1
Jenny	3.8	0.03	2.1	0.7	0.33	>2.1
Linda	11.5	0.26	3.7	2.3	0.62	>3.7
Mean	260.8	6.22	5.2	2.3	0.44	4.9[a]

[a]Exclusive of values limited by maximum depth.

lakes less than 5 m and only 3 exceeding 10 m. The highest values of $\bar{Z}:Z_m$ (mean depth/maximum depth) were found in the shallow trench-free lakes (mean 0.57) and the lowest values in the trenched lakes, both shallow and deep (means 0.31) (Table 2). These ratios reflect the flat-bottomed configuration of the trench-free lakes, and the relatively small area of deep water in the trenched lakes.

Lake areas ranged from 3.8 to 10,311 ha (Table 2). Twenty-seven lakes had areas less than 100 ha, 21 were 100–1000 ha, and 3 lakes exceeded 1000 ha. The largest, Manitou Lake, constituted 39.2% of the total water surface of the island. The shallow trench-free lakes were much smaller (mean 24 ha) than the shallow trenched lakes (mean 117 ha). This smaller size of the shallow trench-free lakes was consistent with the hypothesis that wind action was the mechanism of trench formation or maintenance, or both. The extent of wave action, and hence return water currents, on the windward side of the lake, where most trenches occurred, was determined in part by the fetch of the wind. Thus, the smaller the lake, the lesser was the fetch and the lesser the wave action onshore.

Lake volumes ranged from 0.03 $m^3 \times 10^6$ to 1643.51 $m^3 \times 10^6$ (Table 2). Collectively, the dimictic lakes held 96% of the total volume of island lake water, with 94% contained in the three large lakes, Manitou (61.6%), Kagawong (21.1%), and Mindemoya (11.8%). The volume of the shallow trenched lakes averaged four and one-half times that of the shallow trench-free lakes. However, this difference was in direct proportion to the areas of the lakes in the two categories, and mean depths were very similar.

SEDIMENTS

The sediments of Smoky Hollow Lake evidenced three distinct zones. The uppermost 2–3 cm comprised a flocculent sage-green layer of plant debris, *Gomphosphaeria*, *Chlorococcum*, diatoms (especially *Navicula*), plus ciliates, flagellates, amoebae, chironomids, and *Hyalella*. Beneath this was a more compact, 5-cm layer of grey-black plant debris, *Gomphosphaeria*, blue-green algae, diatoms, and small bivalve shells. Below this a third zone of homogeneous, gelatinous olive-brown mud extended to a depth of several meters.

In Smoky Hollow Lake, as in the other shallow lakes, wind action resulted in periodic agitation and suspension of sediment during the ice-free months. Analysis of sediment cores from Smoky Hollow Lake revealed oxygen was present in trace amounts to a depth of 7 cm in summer, 5 cm in December, and 2 cm in January and only to the water–sediment interface in February. This phenomenon of sediment oxygenation during lake mixing and loss of the oxygenated zone during stagnation has been documented by Gorham (1958) for Esthwaite Water. However, the orange floc of ferric hydroxide reported by Gorham was not observed on the sediment. This may be due to the low concentration of iron in the Manitoulin lakes, an average of 0.25 ppm for the 31 lake waters analyzed.

TEMPERATURE

All but 10 of the lakes failed to stratify in summer and mixed frequently through wind action. Spring and autumnal mixing were not documented in all

of the stratified lakes, but their oxygen profiles suggested that such mixing occurred.

One of the noteworthy features of the temperature conditions of the dimictic lakes was the depth of the thermoclines. In the two largest, Manitou and Kagawong, thermoclines were as deep as 20 and 25 m, respectively, and, in 1965, Mindemoya Lake (Z_m 23 m) ceased to be stratified by late summer (Fig. 4). All of the other dimictic lakes (Fig. 4) were smaller in area and sheltered from the wind,

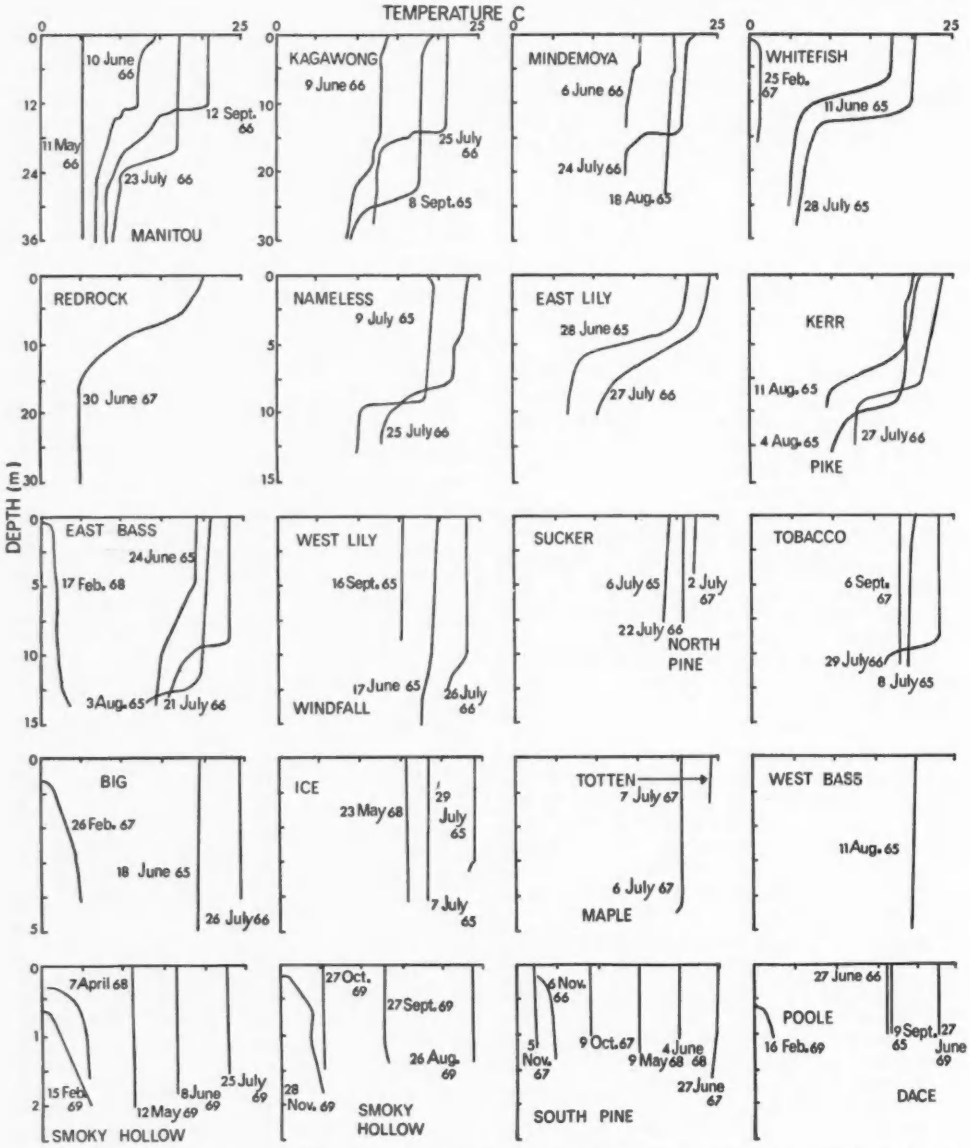

FIG. 4. Temperature profiles of 24 selected lakes, including all dimictic lakes, on various dates. Vertical lines not reaching the surface indicate thickness of ice cover.

and the thermoclines were correspondingly shallower (5–12 m).

The deep polymictic lakes typically were isothermal during summer. Relatively deep lakes, such as Windfall (Z_m 15 m), but with a fetch of several kilometers, failed to stratify (Fig. 4). Temporary stratification was observed only twice: in Tobacco Lake in July 1966 (Fig. 4) and in Linda Lake in May 1969 (not illustrated).

The shallow polymictic lakes were characterized by isothermal conditions in summer, by abbreviated periods of fall cooling and spring warming, and by winter stratification. Smoky Hollow Lake (Fig. 5) cooled rapidly in September–October and froze in November, a month earlier than the deeper lakes. Often the shallow lakes cooled below 4 C from top to bottom, as illustrated by South Pine Lake in November 1967 (Fig. 4), until calm weather permitted an ice-cover to form. Under the ice the temperature of Smoky Hollow Lake rose rapidly close to the bottom, with the greatest increase, from 3 to 5 C, in November. Heating continued through the period of ice-cover with the highest winter temperature of 6.8 C recorded at 1.5 m in early April. The heating of bottom water under the ice was presumed to be due to transfer of heat from the sediments, as discussed recently by Likens and Ragotzkie (1965). Stratification was present at every station on Smoky Hollow Lake during the period of ice-cover. No reverse stratification was observed with warm water immediately beneath the ice as described by Birge (1910) and others since, probably because the ice was almost invariably opaque and covered with a blanket of snow.

During March–April a large volume of exogenous water entered Smoky Hollow Lake under the ice-sheet, as reported by Hill (1967) elsewhere. This terrestrial melt-water was near 0 C and remained close under the ice-sheet, preserving the winter thermal stratification.

The period of winter stagnation of both shallow and deep lakes ended with the loss of ice in mid-April. With its small heat budget, Smoky Hollow Lake warmed quickly to summer temperatures (Fig. 5) and thus showed a relatively brief spring period. Summer maxima tended not to be high for the shallow lakes, with 28 C the highest temperature recorded for Smoky Hollow Lake and 26 C the highest for any other lake. During summer, Smoky Hollow and the other shallow lakes showed diurnal fluctuations of 2–4 degrees C and were polymictic in the sense that they mixed frequently (Hutchinson and Löffler 1956) as a result of wind action, but not in the sense that they underwent daily stratification and mixing.

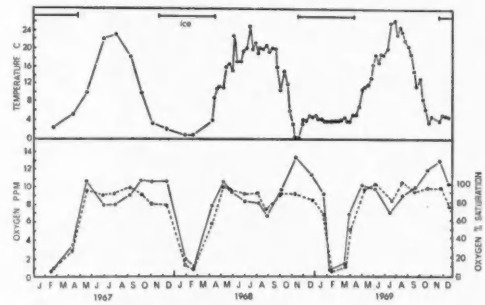

FIG. 5. Temperature and oxygen concentration (solid line) and percent saturation (broken line) at a depth of 1 m in the trench (station 12) on the east side of Smoky Hollow Lake, 1967–69.

Chemical Characteristics

OXYGEN

The observed seasonal variations in oxygen content were consistent with the categories dimictic and polymictic for the lakes. In summer, the dimictic lakes showed three patterns of vertical oxygen distribution (Fig. 6): Nameless Lake,[1] with no reduction in hypolimnial oxygen, was α-orthograde; Manitou, Mindemoya, Whitefish, and Redrock lakes, with some depletion of hypolimnial oxygen, were β-orthograde; Kagawong, East Lily, Kerr, Pike, and East Bass lakes evidenced exhaustion of oxygen at depth and were clinograde. In winter, Whitefish and Mindemoya lakes showed oxygen concentrations near saturation, but East Bass Lake was again clinograde with depletion of oxygen at depth.

Four of the above lakes, Nameless, Whitefish, Redrock and Manitou, showed oxygen maxima in the region of the thermocline and were thus positive heterograde. Only in Nameless and Whitefish lakes was oxygen known to exceed the value at spring overturn, which indicated the excess oxygen had resulted from photosynthesis. In Manitou Lake by late summer (1965), the thermocline reached a depth of 21 m, which was probably below the level of appreciable light penetration (Secchi 7 m), and no photosynthetic-oxygen maximum was present. The three smaller, positive, heterograde lakes showed relatively shallow epilimnia (5–9 m) and thus the thermoclines were at depths of considerable insolation (Secchi 8.1–9.2). The phenomena of insolation, photosynthetic maxima, and warming of water in situ at depth have been discussed previously by Harvey (1967).

[1]Poisoned with rotenone by the owners in 1958 and again with Cooper Tox #6 in 1964 (D. I. Gillespie unpublished data).

The deep polymictic lakes in summer showed oxygen distributed uniformly from top to bottom. The trenched lakes, such as Windfall, West Lily, Sucker, and North Pine, were close to or below air-saturation and no oxygen deficiency was observed at depth. The trench-free lakes, such as Tobacco, Big, and Ice, also were uniformly oxygenated and no temporary vertical differences in oxygen con-

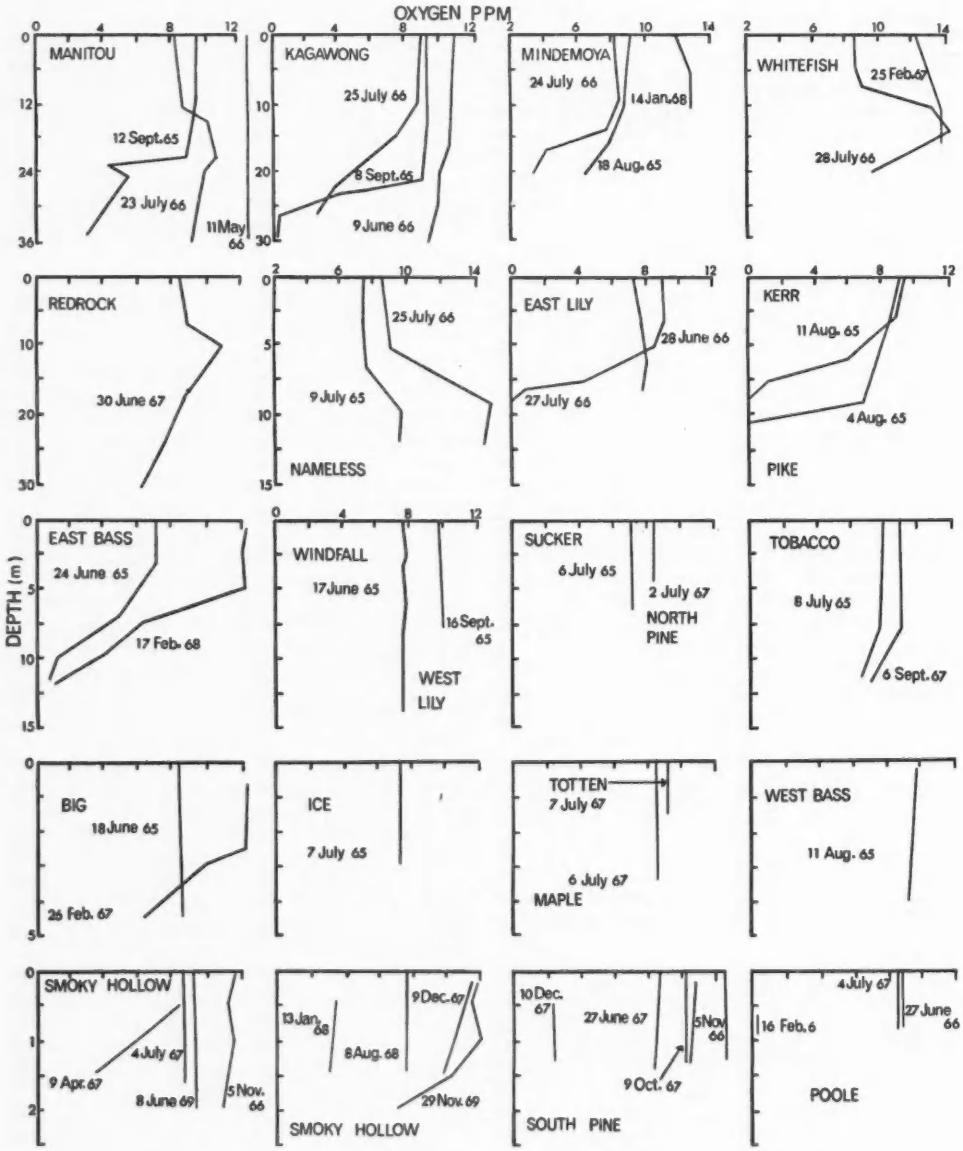

FIG. 6. Profiles of oxygen concentration in 23 selected lakes on various dates.

centration were observed. In winter, Big Lake evidenced some reduction in oxygen at depth and thus showed a β-orthograde distribution curve.

The shallow polymictic lakes, both trenched, such as Maple, West Bass, Smoky Hollow, and South Pine, and trench-free, such as Poole, were close to air-saturation in summer but lost much or all dissolved oxygen from some areas. In Smoky Hollow Lake the percent saturation in the trench (Fig. 5) declined in fall as air-equilibration lagged behind the rate of cooling. Two weeks after an ice-cover formed, in mid-November, oxygen concentration was still high in the upper waters but some depletion had occurred close to the bottom (Fig. 6). The oxygen concentration declined slowly in early winter and more rapidly in January and became minimal in February (Fig. 5).Under the ice, oxygen concentrations at the 14 stations on the lake varied regionally and ranged from 0 to 2 ppm in February 1968, and from 0 to 3.2 ppm in February 1969 (Fig. 7A). During March and April the concentrations rose precipitously as air-saturated surface melt-water entered the lake under the ice. By mid-March they ranged from 1.4 to 8.7 ppm (Fig. 7B) and continued to increase until the ice left the lake in mid-April. During this period when exogenous water was entering under the ice-sheet, some oxygen stratification was observed (Fig. 6), especially close to shore. Air-saturation was reached in early May and the lake remained near saturation throughout the summer (Fig. 5). In trench-free Poole Lake, large areas were devoid of oxygen in mid-February, the highest concentration recorded being 0.5 ppm (Fig. 7). Greenbank (1945) described small pockets of water immediately beneath the ice of Green Lake, Wisconsin, that contained 2–6 ppm of oxygen; no such pockets were found in Smoky Hollow or Poole lakes. In view of the survival of fishes in all but two (Max and Kemp lakes) of the shallow lakes studied, these lakes were not placed in Pennak's (1968) class of "winter anaerobic waters"; rather they were classed simply as shallow polymictic lakes.

That some fish survived winters in the shallow lakes was evidenced by the presence in many of a variety of fishes in the older age-classes, the common species being the white sucker (*Catostomus commersoni*), northern pike, and yellow perch. However, occasional partial kills were observed. Many yellow perch were found dead in Martin Lake in May 1965, soon after the lake became ice-free. Most of the dead perch seen were large, but selective feeding on the smaller individuals, by gulls for example, could not be discounted. In Smoky Hollow Lake small numbers of dead fish were found in areas devoid of oxygen during early spring 1967,

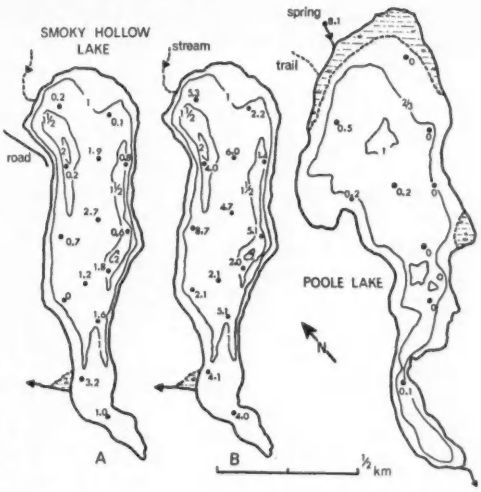

FIG. 7. Oxygen concentrations (ppm) beneath the ice at 14 stations on Smoky Hollow Lake, February 15 (A) and March 21 (B), and at 10 stations on Poole Lake, February 16, 1969.

and a winter-kill of northern pike and yellow perch occurred from late February to March in 1969. Some of the shallow lakes have no outlets and in some the outlet stream was impassable to fish. For this reason, annual reinvasion was discounted as an explanation for the presence of fishes in the shallow lakes generally.

These observations on the survival of fishes in the shallow lakes were somewhat at variance with the reported tolerance of fish to low oxygen. Thompson (1925) concluded from his measurements that oxygen concentrations between 0 and 2 ppm would kill all kinds of fish. Moore (1942) found the highest oxygen tension that killed all yellow perch in 48 hr was 1.5 ppm, and the value for northern pike was 2.3 ppm. In Poole Lake in February 1969, both live and dead fish were present at oxygen concentrations of 0.2–0.5 ppm and a large mass of cyprinids was concentrated in the region of the spring at the north end of the lake. However, these findings were similar to those of Cooper and Washburn (1946) for Green Lake, Michigan.

COMPOSITION

Chemically, the lakes constituted a homogeneous group with similar ionic proportions. The outstanding features were the small amount of colour in the water, the relatively high *p*H, and the dominance of calcium and magnesium.

TABLE 3. Colour, acidity, dissolved solids, and major cations (ppm) of the lakes studied.[a]

Lake	Colour (*Hazen units*)	*p*H	TDS	Hardness as $CaCO_3$	Alkalinity as $CaCO_3$	Ca	Mg	Na	K
Dimictic									
Redrock	5	8.8	235	180	167	33	24	0.4	0.4
Manitou[c]	5	8.2	162	140	112	32	15	1.1	0.7
East Bass	20	8.8	215	168	148	33	11	2.0	1.2
East Lily	5	8.3	227	200	180	43	22		
Pike		8.8[b]	242[b]	190[b]	166[b]				
Whitefish	5	8.9	222	170	153	27	25	0.8	0.5
Mindemoya[c]	5	8.5	220	176	134	38	20	1.4	0.9
Kagawong[c]	5	8.2	171	150	120	34	16	1.1	0.8
Nameless	5	8.4	207	174	150	40	18		
Kerr	15	8.7	265	185	170	33	25	1.0	0.7
Mean	7.8	8.6	217	173	150	34.8	19.6	1.1	0.7
Polymictic									
Trenched, Shallow									
Turtle				110[b]	99[b]				
Perch		8.8[b]	213[b]	170[b]	146[b]				
Long	25	8.1	165	126	103	32	12	1.0	0.7
Smoky Hollow A	15	8.4	219	190	169	41	21		
B	15	8.7	256	194	179	34	26	1.2	1.1
South Pine	10	8.8	225	174	158	30	24	1.0	0.5
Rock	5	8.5	182	158	144	34	18		
Martin		8.7[b]	195	146	124	29	18	0.9	0.6
Kiln		8.6[b]	179[b]	195[b]	176[b]				
Mud	15	8.1	141	126	110	30	6		
Stone's		8.6[b]	179[b]	192[b]	165[b]				
Maple	20	8.2	221	202	177	42	23	1.0	0.8
Falls	5	8.4	196	162	147	36	17	1.0	0.7
Wickett	5	8.4	226	194	177	43	21	1.0	1.0
Young	15	8.3	200	189	173	39	22	1.0	0.6
Totten	5	8.3	114	96	70	20	11	1.0	0.5
West Bass	5	8.3	174	150	125	31	17	1.0	0.5
Mean	11.4	8.5	191	162	142	33.3	17.9	1.0	0.7
Trenched, deep									
Sucker	5	8.0	145	116	105	28	11	1.0	0.5
North Pine		7.9[b]	170[b]	150[b]	130[b]				
Windfall	5	8.8	163	134	116	28	15	0.7	0.5
West Lily	15	7.9	155	104	94	24	10	1.0	0.5
Mean	8.3	8.2	158	126	111	26.7	12.0	0.9	0.5
Trench-free, shallow									
Poole	15	8.9	215	155	135	30	19		
C			379	305	331	78	40	2.0	1.3
Snow	10	8.7	177	146	120	32	16	1.4	1.0
Dace	35	8.1	205	152	134	36	16	1.1	0.4
Owl	25	9.1	235	133	112	24	17		
Deer	25	8.3	225	200	188	47	21	1.0	0.5
Sagigonsing	15	8.2	205	150	126	35	17	6.9	0.9

(*Continued*)

TABLE 3. Colour, acidity, dissolved solids, and major cations (ppm) of the lakes studied.[a] — (*Concluded*)

Lake	Colour (*Hazen units*)	*p*H	TDS	Hardness as $CaCO_3$	Alkalinity as $CaCO_3$	Ca	Mg	Na	K
Portage	10	8.7	255	158	140	36	16	2.0	0.8
Nineteen		8.6[b]	142[b]	140[b]	120[b]				
Max C	5	7.5	145	108	94	26	11	1.0	0.8
Kemp		8.2[b]		160[b]	139[b]				
C	5	7.4	135	114	106	26	12	1.0	0.8
Hog	35	8.6	320	223	216	46	28	1.0	0.7
Pot-Hole		8.1	192[b]	180[b]	170[b]				
Mean	21.3	8.5	217	163	146	35.8	18.8	2.2	0.7
			Trench-free, deep						
Big	10	8.8	180	144	131	30	17	1.4	0.6
Ice	20	8.3	220	176	136	43	16	1.7	0.7
Tobacco	5	8.3	227	176	147	40	18	1.0	0.6
B	10	8.8	209	170	146	26	25	1.3	0.8
Lorne	10	8.6		175	153	40	19	9.0	1.0
Silver[c]	5	8.0	183	160	150	32	19	1.3	0.6
Loon	5	8.4	165	145	145	24	20	0.7	0.5
Burnett	5	8.4	190[b]	157	138	30	19	0.7	0.5
Jenny		8.0[b]	263[b]						
Linda		8.4[b]	205	214	190	50	22	1.5	3.4
Mean	8.6	8.4	204	168	149	36.1	18.8	2.2	1.0

[a]Values listed are for single measurements and were made in summer except as indicated: A, spring; B, fall; C, winter. Means were calculated from summer values plus fall data for Smoky Hollow Lake.

[b]Field determinations.

[c]Source: Water Survey Report No. 14, Canada Department of Mines and Technical Surveys.

Water colour averaged 12 and ranged from 5 to 35 Hazen units (Table 3) for the 37 lakes tested. Colour was correlated weakly with total dissolved solids (TDS) ($r = 0.40$; $P < 0.02$) but not with *p*H ($r = 0.002$; $P > 0.9$). Among lake categories the shallow trench-free lakes averaged 21.3 units and were of significantly greater colour (*t*-test, $P = 0.05$–0.001) than the lakes of the other four categories. This relative clarity of the lakes generally was reflected in the depths of the Secchi readings obtained, 2.1–9.2 m (Table 2). The dimictic lakes showed the highest Secchi values and averaged 5.7 m. In all of the shallow trench-free lakes, Secchi readings were limited by maximum depth.

In *p*H, the lakes averaged 8.5 and ranged from 7.9–9.1, with all but two of the lakes in the narrow range of 7.9–8.9. Lakes such as Maple, Hog, and Pot-Hole were basic in *p*H though they evidenced a brown water colour. Lake *p*H was correlated significantly with TDS ($r = 0.36$; $P \sim 0.01$) and weakly with alkalinity ($r = 0.21$; $P \sim 0.05$). There were no significant differences (by *t*-test) between the five categories of lakes.

Summer measurements of TDS ranged from 114 to 320 and averaged 202 ppm for 47 lakes. No significant differences were found between lake categories, between lakes in the northern and southern parts of the island, or between lakes in the eastern, central, and western portions of the island. TDS was correlated strongly with alkalinity ($r = 0.72$; $P < 0.001$), hardness ($r = 0.71$; $P < 0.001$), calcium ($r = 0.55$; $P < 0.001$), and magnesium ($r = 0.74$; $P < 0.001$), but not with sodium ($r = -0.03$; $P < 0.9$) or potassium ($r = 0.13$; $P \sim 0.5$). In Smoky Hollow Lake, TDS increased 17% from spring to fall. More marked was the winter increase, as pure water froze onto the bottom of the ice sheet. In Poole Lake TDS reached 379 ppm in mid-February, an increase of 76% over summer values (Table 3). With the inflow of melt-water under the ice of Smoky Hollow Lake in March, the TDS of the lake became markedly stratified. At station 10 on the east side of the lake, TDS was 120 ppm at 30 cm depth, 145 ppm at 60 cm, 235 ppm at 1 m, and 310 ppm at 2 m beneath the ice. This stratification was less marked at stations farther offshore.

Hardness ranged from 92 to 223 and averaged 140 ppm $CaCO_3$. On the hardness scale given by Brooks and Deevey (1963) most of the lakes would be classified as "hard" (HCO_3 > 84 ppm). With calcium concentrations of 20–50 ppm, all of the lakes would fall in the "Ca-rich" class of Ohle (1934). Magnesium content was high in relation to calcium, averaging half the calcium content in each category of lakes. Despite considerable variation in the Mg:Ca ratio in individual lakes, these ions were strongly correlated ($r = 0.43$; $P \sim 0.001$). The ratio of Mg:Ca was 0.53 for 40 island lakes. This is notably higher than the ratio of 0.29 calculated from the data of Wetzel (1966) on 10 marl lakes in Indiana, and the ratio of 0.18, based on calcium of 34.1 ppm, in the table of standard composition of calcareous waters offered by Rodhe (1949). Some of the deeper lakes on the island intersected several strata of different composition, such as dolomite, shale, and limestone, and some lakes, both shallow and deep, straddled different formations. For this reason it was not possible to relate specific water compositions to rock types. Deposition of marl was observed in many of the lakes; all but eight of the lakes were harder than the concretion-forming marl lake described by Eyster (1958). *Chara* was present in at least 16 lakes.

Sodium and potassium were present in unusually low concentrations. Sodium averaged 1.5 ppm and ranged from 0.4 to 9.0 ppm for 35 lakes. Thus, sodium was about one-sixth as abundant as tabled in Rodhe's (1949) standard composition, at a calcium concentration of 34.1 ppm. No explanation was found for the higher concentrations of sodium in Sagigonsing and Lorne lakes (Table 3). Potassium averaged 0.8 and ranged from 0.4 to 3.4 ppm, with Linda Lake alone much above average. Thus, potassium was very close to the mean concentration of 1 ppm for most dilute waters (Hutchinson 1957) but was less than one-quarter of the appropriate value in Rodhe's (1949) table.

Some of the shallow lakes harbour numbers of migratory waterfowl, and five lakes, Wickett (a bird sanctuary), Owl, Smoky Hollow, Falls, and Young, were examined for evidence of guanotrophy. Free ammonia ranged from 0.02 to 0.10, total Kjeldahl 0.46 to 2.80, nitrite 0.003 to 0.005, and nitrate 0.01 to 0.07 ppm. Ammonia and Kjeldahl nitrogen values for Owl Lake were higher by approximately four times, but these waters could not be described as guanotrophic.

Iron was present at low concentrations which ranged from 0.05 to 2.70 ppm Fe (mean 0.25 ppm) for 31 lakes, all but two lakes containing less than 0.4 ppm. Chloride showed a mean concentration of 1.8 ppm (range 1–4 ppm) for the 12 lake waters analyzed and thus was present at about one-fifth of the appropriate value in Rhode's (1949) table of standard composition.

Acknowledgments

This study was supported by grants from the National Research Council of Canada and the Canadian National Sportsmen's Show. The interest and assistance of the Ontario Department of Lands and Forests is gratefully acknowledged. The Ontario Water Resources Commission provided many of the water analyses. Appreciation is extended to W. Allison, R. J. Beamish, J. M. Casselman, R. Dobko, B. W. Fallis, D. Powell, and A. Temple for their aid in making field measurements. In the laboratory C. J. R. Zaharchuk and J. Blythe assisted with analysis of the data.

BIRGE, E. A. 1910. The apparent sinking of ice in lakes. Science 32: 81–82.

BRINKHURST, R. O., K. E. CHUA, AND E. BATOOSINGH. 1969. Modifications in sampling procedures as applied to studies on the bacteria and tubificid oligochaetes inhabiting aquatic sediments. J. Fish. Res. Bd. Canada 26: 2581–2593.

BROOKS, J. L., AND E. S. DEEVEY, JR. 1963. New England, p. 117–162. *In* D. G. Frey [ed.] Limnology of North America. Univ. of Wisconsin Press, Madison, Wisc.

CHAPMAN, L. J., AND D. F. PUTNAM. 1966. The physiography of Southern Ontario. Univ. of Toronto Press, Toronto, Ont. 386 p.

COOPER, G. P., AND G. N. WASHBURN. 1946. Relation of dissolved oxygen to winter mortality of fish in Michigan lakes. Trans. Amer. Fish. Soc. 76: 22–33.

EYSTER, C. 1958. Bioassay of water from a concretion-forming marl lake. Limnol. Oceanogr. 3: 455–458.

FRANCIS, J. R. D. 1953. A note on the velocity distribution and bottom stress in a wind-driven water current system. J. Mar. Res. 12: 93–98.

GORHAM, E. 1958. Observations on the formation and breakdown of the oxidized microzone at the mud surface in lakes. Limnol. Oceanogr. 3: 291–298.

GREENBANK, J. 1945. Limnological conditions in ice-covered lakes, especially related to winter-kill of fish. Ecol. Monogr. 15: 343–392.

HARVEY, H. H. 1961. Analysis of dissolved nitrogen in fish blood. Can. J. Zool. 39: 904–909.

1967. Supersaturation of lake water with a precaution to hatchery usage. Trans. Amer. Fish. Soc. 96: 194–201.

HILL, H. 1967. A note on temperatures and water conditions beneath lake ice in spring. Limnol. Oceanogr. 12: 550–552.

HUTCHINSON, G. E. 1957. A treatise on limnology. Vol. 1. Geography, physics and chemistry. John Wiley and Sons Ltd., New York, N.Y. 1015 p.

HUTCHINSON, G. E., AND H. LÖFFLER. 1956. The thermal classification of lakes. Proc. Nat. Acad. Sci. 42: 84–86.

KINSMAN, B. 1965. Wind waves their generation and propagation on the ocean surface. Prentice-Hall Inc., Englewood Cliffs, New Jersey. 676 p.

LIKENS, G. E., AND R. A. RAGOTZKIE. 1965. Vertical water motions in a small ice-covered lake. J. Geophys. Res. 70: 2333–2344.

MOORE, W. G. 1942. Field studies on the oxygen requirements of certain fresh-water fishes. Ecology 23: 319–329.

OHLE, W. 1934. Chemische und physikalische Untersuchungen norddeutscher Seen. Arch. Hydrobiol. 26: 386–464, 584–658.

PENNAK, R. W. 1968. Field and experimental winter limnology of three Colorado mountain lakes. Ecology 49: 505–520.

RODHE, W. 1949. The ionic composition of lake waters. Verh. Int. Ver. Limnol. 10: 377–386.

THOMPSON, D. H. 1925. Some observations on the oxygen requirements of fishes in the Illinois River. Ill. Natur. Hist. Surv. Bull. 15: 423–437.

VAN DORN, W. G. 1953. Wind stress on an artificial pond. J. Mar. Res. 12: 249–276.

WETZEL, R. G. 1966. Productivity and nutrient relationships in marl lakes. Verh. Int. Ver. Limnol. 16: 321–332.

The Stress of Formalin Treatments in Rainbow Trout (*Salmo gairdneri*) and Coho Salmon (*Oncorhynchus kisutch*)

GARY WEDEMEYER

U.S. Bureau of Sport Fisheries and Wildlife
Western Fish Disease Laboratory, Bldg. 204, Sand Point N.S.A.,
Seattle, Washington 98115, USA

WEDEMEYER, G. 1971. The stress of formalin treatments in rainbow trout (*Salmo gairdneri*) and coho salmon (*Oncorhynchus kisutch*). J. Fish. Res. Bd. Canada 28: 1899–1904.

Changes in gill function, acid–base balance and pituitary activation occurring during standard 200 ppm formalin treatments of juvenile rainbow trout (*Salmo gairdneri*) and coho salmon (*Oncorhynchus kisutch*) were compared. Plasma Cl^-, Ca^{++}, total CO_2, and interrenal vitamin C in the trout declined continuously and in proportion to the exposure time, but the salmon were able to maintain these metabolic parameters at approximately initial levels. Blood *p*H and alkaline reserve regulation of the salmon was also less affected by formalin treatments, especially during prolonged exposures. The oxygen consumption of both species was depressed, but substantially more so in the trout than could be accounted for by decreased ventilation rates. Little frank hemolysis occurred in either species, but there was a significant bilirubinemia in the trout.

WEDEMEYER, G. 1971. The stress of formalin treatments in rainbow trout (*Salmo gairdneri*) and coho salmon (*Oncorhynchus kisutch*). J. Fish. Res. Bd. Canada 28: 1899–1904.

L'auteur compare les variations de la fonction branchiale, de l'équilibre acido–basique et de l'activation hypophysaire de jeunes spécimens de truites arc-en-ciel (*Salmo gairdneri*) et de saumons coho (*Oncorhynchus kisutch*) soumis à des traitements standards à la formaline à 200 ppm. Chez les truites, le Cl^- plasmique, Ca^{++}, CO_2 total et la vitamine C interrénalienne diminuent sans interruption et proportionnellement à la durée d'exposition. Les saumons maintiennent ces paramètres à peu près à leurs valeurs initiales. Le traitement à la formaline affecte moins le *p*H sanguin et le réglage de la réserve alcaline des saumons que ceux des truites, surtout au cours d'expositions prolongées. La consommation d'oxygène diminue chez les deux espèces, mais, chez les truites, à un degré beaucoup plus marqué que ne le justifie l'abaissement du taux de ventilation. Très peu d'hémolyse franche se produit chez l'une ou l'autre espèce, mais il y a nettement bilirubinémie chez la truite.

Received June 25, 1971

FORMALIN has had a long history of use in hatcheries for the control of such external parasites of fishes as *Costia* sp. and *Gyrodactylus* sp. (Rucker 1970). However, at the commonly used dilutions of 167 ppm (1:6000) to 250 ppm (1:4000), its toxicity to salmonids is sometimes erratic. A mortality of 10–20% may occur immediately upon treatment at normally safe levels or mortalities may be delayed by several hours (Wood 1968). Toxicity is also quite species-dependent with rainbow trout (*Salmo gairdneri*), being more sensitive than other salmonids. Attempts to correlate this variable toxicity to the water chemistry, including metal ions, *p*H, and ammonia, have met with only limited success, but among rainbow trout, strain differences appear to be involved (Rucker et al. 1963; J. Larmoyeux personal communication).

Pathological changes involving the gill lamellar epithelium are widely recognized consequences of formalin treatments, and coho salmon (*Oncorhynchus kisutch*) are more resistant than rainbow trout to such damage (Rucker 1962). However, little is known about the physiological implications of these gill changes. Since knowledge of the physiological dysfunctions caused by formalin could help explain the species variation and also form the basis for less stressful treatments, experiments were designed to evaluate and compare the extent of blood dyscrasia and metabolic dysfunction occurring in a formalin-resistant (coho salmon) and a susceptible (rainbow trout) juvenile salmonid.

Printed in Canada (J2216)

Materials and Methods

Groups of juvenile coho salmon and rainbow trout were exposed to 200 or 400 ppm formalin in aerated water of 20 ppm hardness ($CaCO_3$) at 10 C. The fish were obtained from the Quilcene National Fish Hatchery and acclimated to the laboratory several weeks before use. Generally, 20–40-g fish were exposed in groups of 50, using a fish/water ratio of about 1:40. Subsamples of 5–10 fish were removed at the desired time intervals and caudal arterial blood samples taken for evaluation of acid–base balance and gill, kidney, and liver function. This was done by measuring O_2 consumption, plasma total CO_2, HCO_3^-, Cl^-, Ca^{++}, bilirubin, and whole blood *p*H using previously described methods (Wedemeyer and Chatterton 1971; Wedemeyer 1970). Pituitary-interrenal activation, a direct measure of the stress response to formalin, was evaluated by determining anterior kidney vitamin C depletion during exposure (Wedemeyer 1969). All results are shown as mean values ± standard error and the Man-Whitney U-test was used for statistical analyses. However, it should be kept in mind that statistical significance does not necessarily imply biological significance.

Reagent grade (Baker) formalin containing methanol as a preservative was used to duplicate hatchery practice.

Results and Discussion

To evaluate both physiological gill dysfunction and the time needed for recovery, oxygen consumption, plasma Ca^{++}, Cl^-, and total CO_2 were measured during formalin exposure. The 200-ppm formalin level was selected as representative of normal hatchery practice. Figure 1 shows plasma Cl^- and arterial total CO_2 as a function of treatment time at 200 and 400 ppm, respectively. At the usual 200-ppm formalin level, the salmon maintained their plasma chloride at approximately initial levels even during an extended treatment, whereas the trout lost chloride continuously during the same period. After a 1-hr exposure, the decrease in plasma Cl^- had reached statistical significance (P = 0.01). By the end of 6 hr, the trout had lost about 30% of their initial plasma chloride and many were moribund, whereas the salmon showed no adverse behavioral changes and were apparently unaffected. Loss of blood calcium followed a similar pattern (Fig. 2). The small decline in calcium levels shown by the salmon was not statistically significant (P = 0.05). Similarly, the small increase at 6 hr in the trout was not significantly different from the 4-hr value. That the decrease in blood concentration of both Ca^{++} and Cl^- in the trout was not due to water influx (hemodilution) was shown by the fact that blood total protein levels remained fairly constant and not significantly different from the controls (P = 0.05) during formalin exposure:

Exposure time (*hr*)	Blood total protein (*g/100 ml*)
0	3.24±0.42
1	3.44±0.66
3	3.32±0.33
6	3.95±0.11

In contrast to these results, which are presumably related to kidney or lamellar epithelium ac-

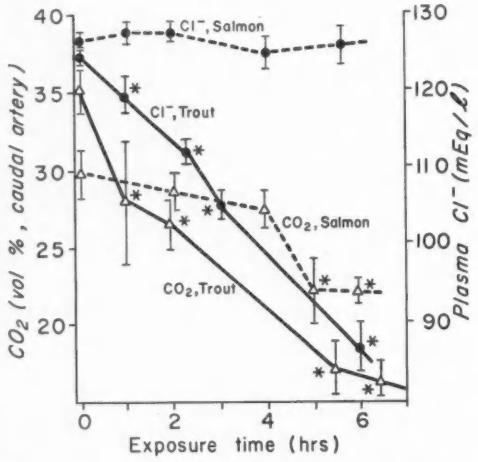

FIG. 1. Changes in plasma Cl^- and CO_2 levels of juvenile rainbow trout and coho salmon during exposure to formalin at 200 or 400 ppm, respectively; 10 C. *Indicates significant difference from control values (P = 0.05).

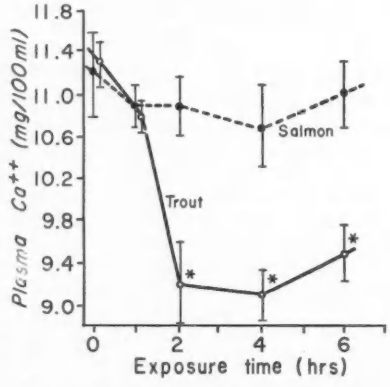

FIG. 2. Plasma calcium levels in juvenile coho salmon and rainbow trout during exposure to formalin; 200 ppm, 10 C. *Indicates significant difference from control values (P = 0.05).

tive transport dysfunction, eliciting any marked change in the arterial CO_2 level (gas transport) of either fish required exposure to at least 400 ppm formalin. Under these conditions, loss of plasma total CO_2 paralleled loss of plasma chloride. The trout suffered a fairly rapid continuous decline that reached significance ($P = 0.05$) after an hour, whereas the salmon lost CO_2 much more slowly, the decrease becoming significant only after about 5 hr exposure. As mentioned, plasma CO_2 levels were relatively unaffected in both species by a "normal" 200 ppm formalin treatment.

The effects of formalin on gas exchange were further evaluated by measuring O_2 consumption and ventilation rates of groups of 5–10 trout and salmon held in a metabolism chamber during 200-ppm formalin treatments. As expected, the salmon suffered the least decrease in ability to extract (or utilize) oxygen from water and the decline that did occur was partially reversed if the formalin exposure was prolonged (Fig. 3). The oxygen consumption of the trout steadily declined, and at the end of 1 hr was reduced to about 50% of the control value as compared to a 25% decrease for the salmon. The ventilation rate of the trout during this period had declined only about 15% and that of the salmon about 10%. This undoubtedly accounted for some of the decreased O_2 consumption, but the Ca^{++}, Cl^-, and CO_2 data indicate that interference with ion and gas transport mechanisms was also involved. Evidently, the histological findings of Rucker (1962), that formalin treatments cause substantial gill lamellar epithelial hypertrophy and separation in rainbow trout but not in coho salmon, have practical physiological significance.

Additional work revealed that formalin treatments can also cause disturbances in acid–base balance (Fig. 4, 5). When trout were exposed to 200 ppm formalin, the blood *p*H gradually declined in proportion to exposure time, but the *p*H

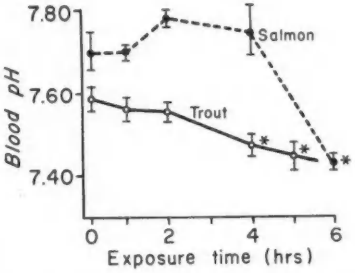

FIG. 4. Blood *p*H (caudal artery) of juvenile rainbow trout and coho salmon during exposure to formalin; 200 ppm, 10 C. *Indicates significant difference from control values ($P = 0.05$).

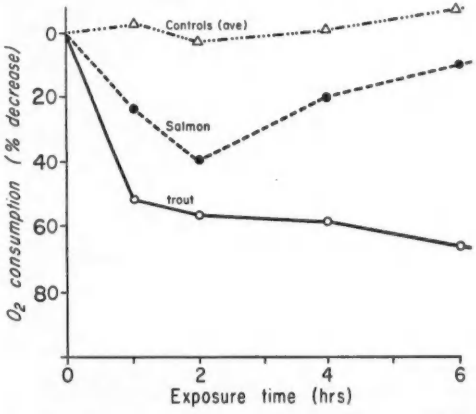

FIG. 3. Oxygen consumption of juvenile rainbow trout and coho salmon during exposure to formalin; 200 ppm, 10 C.

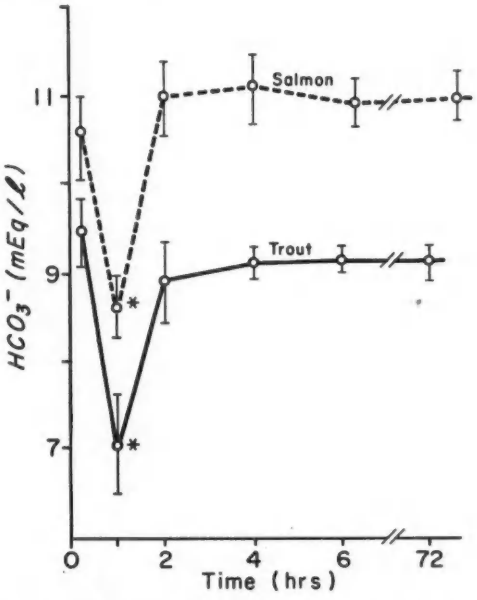

FIG. 5. Depletion of alkaline reserve of juvenile rainbow trout and coho salmon during a 1-hr, 200-ppm formalin treatment, 10 C. Fresh water was introduced after the 1-hr subsample was taken. *Indicates significant difference from control values ($P = 0.05$).

decrease was not statistically significant until the fish had become moribund after about 4 hr. In coho salmon, a small nonsignificant alkaline shift sometimes occurred during the earlier stages, but by 6 hr, the blood *p*H had declined significantly ($P = 0.05$) and approximated that of the moribund trout. As before, the salmon appeared to be unaffected by this formalin regimen and thus the biological significance of this relative acidosis may be questioned even though the criteria for statistical significance were met. Since the alkaline *p*H shift in the coho was concomitant with only a small decrease in arterial CO_2 levels, it is unlikely that respiratory alkalosis was responsible. In fact, as previously mentioned, there was a 10–15% decrease in the respiratory rate of both these fish during formalin exposure.

In neither species did blood *p*H change appreciably during a 1-hr treatment at 200 ppm. At this more usual exposure time, the plasma bicarbonate level was a better indicator of early changes in acid–base balance. The alkaline reserve of both fishes dropped sharply and significantly ($P = 0.05$) during the hour treatment and, after fresh water was introduced, climbed to approximately its initial value within another hour (Fig. 5).

A striking difference in the ability of these two fishes to maintain an alkaline reserve was revealed when the 200-ppm formalin treatment time was prolonged (Fig. 6). As with the other metabolic parameters, coho salmon were also better able to regulate plasma bicarbonate levels than were rainbow trout. In the salmon, correction of the base deficit began during the exposure period and was essentially complete by 24 hr. In contrast, the surviving trout were not fully compensated even after 96 hr, although by then their bicarbonate levels were approaching initial values. In both instances, fresh water was introduced after 6 hr.

By analogy to the sequelae of formaldehyde metabolism in the higher vertebrates, it seemed probable that folic acid would be involved in the acid–base aspects of formalin toxicity (Herken et al. 1969). In the higher vertebrates, the severity of the acidosis that develops due to formic acid retention is inversely proportional to the size of the metabolic folate pool. In the present work, investigations of this effect were limited to the trout, since alkaline reserve depletion in the salmon was less severe.

Rainbow trout were given folic acid per os, 50 mg/kg, for 4 days followed by a 1-hr 200-ppm formalin treatment 16 hr after the last dosage. Again using plasma bicarbonate as a measure of the alkaline reserve, the resulting depletion and recovery were about the same as without folic acid pretreatments (Fig. 7, cf. Fig. 4).

In contrast, treatment with three successive daily doses (0.8 mg/kg) of the folic acid inhibitor 4-amino-10-methyl folic acid (Methotrexate) prior to a 1-hr 200 ppm formalin treatment, precipitated an acidosis qualitatively similar to that reported during formaldehyde metabolism in the Methotrexate-treated rat (Herken at al. 1969). However, a larger dose was required and the main effect was to prolong the depletion time of the alkaline

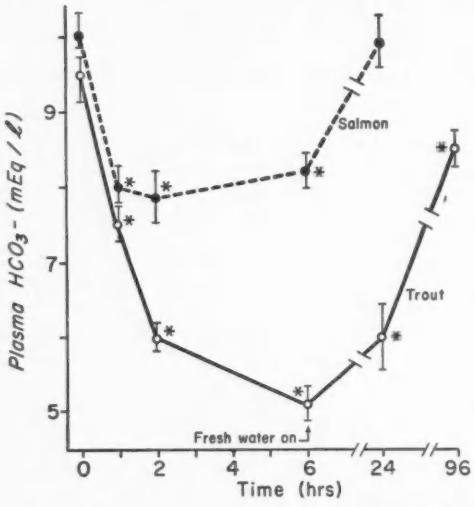

FIG. 6. Depletion of the alkaline reserve of juvenile rainbow trout and coho salmon during exposure to formalin; 200 ppm, 10 C. *Indicates significant difference from control values ($P = 0.05$).

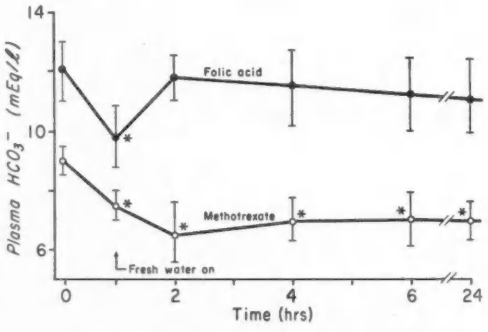

FIG. 7. Effects of folic acid and methotrexate on alkaline reserve depletion in juvenile rainbow trout during a 1-hr formalin treatment; 200 ppm, 10 C. *Indicates significant difference from control values ($P = 0.05$).

reserve curve (Fig. 7). There was not the usual sharp alkaline rebound when fresh water was introduced, and recovery to preexposure bicarbonate levels was incomplete even at 24 hr when the experiments were terminated. Significantly, blood *p*H remained relatively constant, indicating a compensated metabolic (or respiratory) acidosis.

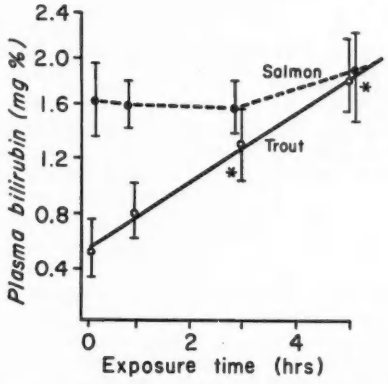

FIG. 8. Plasma bilirubin levels in juvenile coho salmon and rainbow trout during exposure to formalin; 200 ppm, 10 C. *Indicates significant difference from control values ($P = 0.05$).

Thus, folic acid appears to play a role in the metabolism of formaldehyde in fishes as it does in the higher vertebrates. Formate, the principal metabolite of formaldehyde in the higher vertebrates and the agent presumably responsible for the acidosis (Kendal and Ramanathan 1952), could not be reliably demonstrated in blood or tissue of either fish.

Under the treatment conditions used, formalin exposure resulted in little visible hemolysis in the blood-collecting tubes, except after several hours exposure. However, since others have noted blood dyscrasias, including hemolytic changes in rainbow trout (J. Larmoyeux personal communication), hemoglobin degradation was suspected. Plasma bilirubin was selected as a likely index to detect such changes. Only the rainbow trout showed any significant increase in bilirubin levels, even after prolonged exposure to 200 ppm formalin (Fig. 8). As expected, hematocrit and hemoglobin measurements proved too insensitive to detect hemoglobin degradation of this magnitude. Thus, although the increased bilirubin levels (in the trout) were statistically significant, their biological significance is probably slight.

Adrenal hyperplasia has been noted in trout exposed to formalin, (J. Larmoyeux personal communication) implying that pituitary activation may occur during formalin treatment. To evaluate this

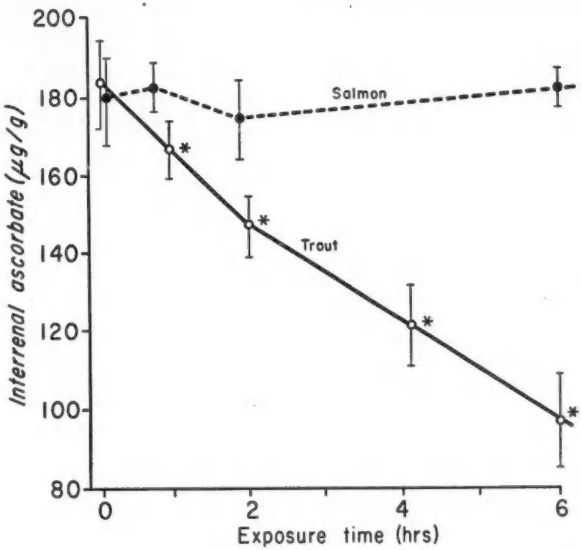

FIG. 9. Interrenal vitamin C depletion in juvenile coho salmon and rainbow trout during exposure to formalin; 200 ppm, 10 C. *Indicates significant difference from control values ($P = 0.05$).

aspect of the stress response to formalin treatments, interrenal vitamin C levels, which are usually taken as an indirect measure of adrenocorticotrophin production (ACTH), were determined in both the salmon and trout and related to exposure time at 200 ppm. Significant pituitary activation apparently occurs only in the trout, with vitamin C depletion beginning immediately after formalin is introduced (Fig. 9). The depletion became significant (P = 0.05) after 1 hr exposure; after 6 hr, when many of the trout were moribund, vitamin C levels had fallen to about half of their initial value. In contrast, coho salmon maintained their vitamin C reserves, implying that formalin treatments do not stress them enough to require much ACTH production. Thus, although both species will usually survive a 200-ppm treatment, formalin apparently does impose a much greater metabolic load on rainbow trout than on coho salmon, aside from inflicting gill pathology; it is this type of stress that is reflected in the declining vitamin C levels. Wedemeyer (1969) showed that feeding high vitamin C diets to trout provides erratic protection against stress-induced ascorbate depletion.

The previously reported hypertrophy and separation of the gill epithelial layer from the lamellar-supporting cells, which occur in formalin-treated rainbow trout but less extensively in coho salmon, may be partly responsible for some of the differences in response of these two species to formalin treatments. However, other factors are also involved. Coho salmon can regulate their blood alkaline reserve, plasma Cl^-, Ca^{++}, CO_2, and interrenal vitamin C levels better than rainbow trout. Ventilation rates of both species fall 10–15% during formalin exposure, but oxygen consumption of the trout declines much more than that of the salmon. Thus, formalin treatments seem to be a more severe stress to rainbow trout. Part of the explanation for the greater toxicity of formalin to the trout must lie in their relative inability to maintain a "normal" metabolism during treatments. Awareness of the internal metabolic changes, short of actual death, caused by various formalin regimens should make it possible to define treatment conditions that will cause minimum stress.

Acknowledgments

Technical assistance of N. Buroker and K. Chatterton is gratefully acknowledged.

HERKEN, W., N. RIETBROCK, AND D. HENSCHLER. 1969. Zum Mechanismus de Methanolvergiftung. Toxisches Agens und Einfluss des Saure-Basenstatus auf die Giftwirkung. Arch. Toxikol. 24: 214–228.

KENDAL, L. P., AND A. W. RAMANATHAN. 1952. Liver alcohol dehydrogenase ester formation. Biochem. J. 52: 430–438.

RUCKER, R. 1962. *In* Progress in sport fishery research, p. 13. U.S. Bur. Sport Fish. Wildlife Circ. 160: 118 p.

RUCKER, R., W. TAYLOR, AND D. TONEY. 1963. Formalin in the hatchery. Progr. Fish-Cult. 25: 203–207.

RUCKER, R. 1970. Fish therapy: past, present and future. Univ. Wash. Coll. Fish. 50th Anniv. Symp. Seattle. (In press)

WEDEMEYER, G. 1969. Stress-induced ascorbic acid depletion and cortisol production in two salmonid fishes. Comp. Biochem. Physiol. 29: 1247–1251.

WEDEMEYER, G. 1970. Stress of anesthesia with MS-222 and benzocaine in rainbow trout (*Salmo gairdneri*). J. Fish. Res. Bd. Canada 27: 909–914.

WEDEMEYER, G., AND K. CHATTERTON. 1971. Some blood chemistry values for the juvenile coho salmon. J. Fish. Res. Bd. Canada 28: 606–608.

WOOD, J. W. 1968. Diseases of Pacific salmon: their prevention and treatment. State of Wash. Dep. Fish., Hatchery Div. 99 p.

OBITUARY

Maurice Aloysius Foley

1921-1971

It is with deep regret that the death of Mr M. A. Foley, who was an outstanding engineer with the Department of Fisheries and the Fisheries Research Board of Canada for many years, is reported. Mr Foley died suddenly at his home in Ottawa on February 10, 1971 at the age of 50. He is survived by his wife and three children and his mother.

Mr Foley was born and educated in Halifax and graduated from the Nova Scotia Technical College in 1943 with a degree in mechanical engineering. Immediately upon graduation, he joined the Royal Canadian Navy and served as an engineer officer in the North Atlantic.

On demobilization in late 1945, he joined the Fisheries Research Board at Halifax. His early work was associated with the development of mechanical equipment for the fish processing industry, particularly with smokers and dryers.

In 1951 he transferred to St. John's as officer-in-charge of the Technological Unit of the Fisheries Research Board in Newfoundland. His work there was primarily concerned with salt fish drying and refrigeration.

Mr Foley moved to Ottawa in 1959 as Senior Engineer with the Industrial Development Branch of the Department of Fisheries and in 1967 became Chief of the Engineering Division of the Inspection Branch, a position which he occupied until his death.

During his career, Mr Foley was active in various professional engineering associations, both in Canada and internationally. During his later years in the Department, Mr Foley's activities became largely associated with refrigeration and refrigerated transport, a field in which he gained an international reputation.

Because of his friendly personality and sound knowledge, Mr Foley had an extremely good working relationship with his associates and the fishing industry.

G. G. ANDERSON

NOTES

Factors Affecting Respiration Rates of Winter Flounder (*Pseudopleuronectes americanus*)

R. A. VOYER AND G. E. MORRISON

National Marine Water Quality Laboratory
West Kingston, Rhode Island, USA

VOYER, R. A., AND G. E. MORRISON. 1971. Factors affecting respiration rates of winter flounder (*Pseudopleuronectes americanus*). J. Fish. Res. Bd. Canada 28: 1907–1911.

In one series of experiments, average rates of oxygen consumed by winter flounder at 10 C were 35 and 55 mg O_2/kg of body weight per hour at 3.5 and 8.6 mg dissolved oxygen (DO)/liter, respectively. At 20 C the average rates of oxygen uptake were 70 at 3.2 mg DO/liter and 97 at 6.3 mg DO/liter. Oxygen consumption rates were significantly greater ($P < .05$) at 20 C than at 10 C. In two of the three experiments, rates of oxygen uptake were significantly lower ($P < .05$) among groups of winter flounder maintained at the reduced dissolved oxygen concentrations for 15–23 hr. No dissolved oxygen–temperature interactions were apparent.

Results of a second series of experiments indicated respiration rates of winter flounder increased linearly with weight along regression lines having slopes of 0.792 (20 C — 6.9 mg DO/liter), 0.785 (20 C — 4.3 mg DO/liter), 0.720 (10 C — 8.7 mg DO/liter), and 0.746 (10 C — 4.3 mg DO/liter).

VOYER, R. A., AND G. E. MORRISON. 1971. Factors affecting respiration rates of winter flounder (*Pseudopleuronectes americanus*). J. Fish. Res. Bd. Canada 28: 1907–1911.

Une série d'essais révèle que le taux moyen de consommation d'O_2 de la plie rouge à 10 C est de 35 et 55 mg O_2/kg de poids vif par heure à 3.5 et 8.6 mg OD/liter, respectivement. A 20 C, le taux moyen d'absorption d'O_2 est de 70 à 3.2 mg OD/liter et 97 à 6.3 mg OD/liter. Le taux de consommation d'O_2 est nettement plus élevé ($P < .05$) à 20 C qu'à 10 C. Au cours de deux des trois expériences, le taux de consommation d'O_2 fut appréciablement plus faible ($P < .05$) chez les plies rouges maintenues pendant 15–23 h à de faibles teneurs en oxygène dissout. Il n'y a pas d'interaction apparente entre oxygène dissout et température.

Une deuxième série d'essais démontre que le taux respiratoire de la plie rouge augmente proportionnellement au poids, suivant une droite de régression à pente de 0.792 à 20 C et 6.9 mg OD/liter, 0.785 à 20 C et 4.3 mg OD/liter, 0.720 à 10 C et 8.7 mg OD/liter, et 0.746 à 10 C et 4.3 mg OD/liter.

Received June 14, 1971

WINTER flounder, *Pseudopleuronectes americanus* (Walbaum), are found along the Atlantic coast of North America from Labrador to Georgia. The species is one of the most important flat fishes. The annual catch exceeds 20 million pounds (Topp 1965). Fry and small winter flounder are usually found in the shallow waters of enclosed bays, estuaries, and harbors, whereas the larger fish extend their ranges into deeper waters (Bigelow and Schroeder 1953). Winter flounder have also been taken from brackish waters of river mouths (Hildebrand and Schroeder 1928). In estuarine areas, it is likely that winter flounder would be exposed to fluctuations of dissolved oxygen, temperature, and salinity, as well as other stressful agents, such as pollutants.

There appears to be little quantitative information available to describe the effects of dissolved oxygen and temperature on winter flounder. It was therefore the objective of this preliminary study to determine the effects of various combinations of dissolved oxygen and temperature on rates of oxygen uptake by juvenile winter flounder.

Knowledge of factors affecting respiration rates of fishes can be applied to the practice of fishery management (Winberg 1956). Oxygen consumption

Printed in Canada (J2200)

rates can also be used as a means of assessing the responses of fishes to environmental conditions (Fry 1957: Brett 1970). Information regarding metabolic activity of fishes collected under controlled conditions may also provide guidelines for evaluating the effect of pollutants on fishes.

Materials and methods — Three experiments were conducted at the National Marine Water Quality laboratory in West Kingston, Rhode Island. The experimental design was a factorial arrangement of treatments consisting of two levels of dissolved oxygen and two temperatures. Each of the four treatment combinations was replicated three times.

In addition, 16 tests were performed on a barge moored in Jerusalem, Rhode Island. In seven of these tests, flounder were simultaneously exposed to two dissolved oxygen levels at 10 C. Also, flounder were simultaneously subjected to two dissolved oxygen concentrations at 20 C in the remaining nine experiments. The two temperature–dissolved oxygen combinations in each test at 10 and 20 C were replicated three times. Three fish were exposed per treatment combination with one fish per replication.

A diagram of the experimental apparatus is presented in Fig. 1. Water of constant temperature was pumped from each of two 500-liter fiberglass tanks (combination water-reservoir, constant-temperature baths covered with black plastic sheeting), partitioned, and passed through two stripping columns (glass tubes 4 cm I.D. × 122 cm long). The dissolved oxygen content was reduced by bubbling nitrogen gas against the downward flow of water in one column; water passing through the second column was unaltered and was considered as air-saturated. Water containing specific levels of dissolved oxygen flowed through four glass capillary tubes to equilibration chambers (Whitworth 1968) immersed in the tanks. Water from each equilibration chamber flowed to four sealed glass jars (respirometers) of approximately 3.8 liters. Overflow from respirometers was returned to the tanks. Water passing through the apparatus was maintained at uniform temperature by a combination of an immersion heater of quartz or of vinyl-coated stainless steel and a titanium immersion cooler. One-liter Erlenmeyer flasks were used as respirometers in experiments with flounder of less than 13.0 g.

Water used at the laboratory was trucked to the laboratory from Narragansett Bay in fiberglass tanks. Water used on the barge was taken from a salt pond. Water from both sources characteristically had a *p*H of 8 and salinities varying from 29 to 32‰.

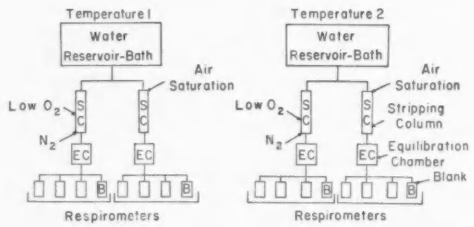

FIG. 1. Diagram of experimental apparatus.

One flounder was placed in each of three respirometers of each treatment combination 21–26 hr before observations were begun; the fourth respirometer (blank) provided an estimate of the dissolved oxygen content of water entering the fish-containing respirometers. For low oxygen treatments, the dissolved oxygen was reduced to desired levels over a 3–6-hr period after the fish had been placed in the respirometers.

At the laboratory, amounts of oxygen used by each fish were estimated three times during the 8-hr test. Dissolved oxygen determinations were made using an oxygen probe (Radiometer Company of Denmark) calibrated by the azide modification of the Winkler method (APHA 1965). On the barge, three estimates of oxygen uptake of each fish were made over a 4–5-hr period, by means of a YSI-Model-54 oxygen probe, standardized using tables with the instrument, and checked as above (APHA 1965). At the end of a test the fish were dripped-dried and weighed to the nearest 0.1 g. Rates of oxygen consumption per unit weight were calculated from differences in the oxygen content of water from blanks and fish-containing respirometers.

Data collected at the laboratory were analyzed by analysis of variance (Ostle 1964) to determine the effects of dissolved oxygen, temperature, and dissolved oxygen–temperature interactions. The results of tests performed on the barge were grouped by temperature and dissolved oxygen levels. These data were analyzed using the method of least squares (Ostle 1964).

Results and discussion — A summary of the data collected at the laboratory (Table 1) shows that at the lower temperatures, average rates ranged from 52 to 60 mg O_2/kg of body weight per hour at 8.4–8.7 mg dissolved oxygen (DO)/liter, and from 33 to 37 mg O_2/kg per hour at 3.2–3.8 mg DO/liter. In comparison, rates at the higher temperatures ranged from 74 to 127 mg O_2/kg per hour at 6.3–6.5 mg DO/liter, and from 61 to 78 mg O_2/kg per hour at 2.7–4.0 mg DO/liter. Rates of oxygen consumption were significantly greater ($P < .05$) at the higher than at the lower temperature. The differences in oxygen consumption rates between groups of flounder exposed to the two dissolved oxygen levels were significant ($P < .05$) in two of three experiments.

In addition, analysis of the data also indicated no apparent dissolved oxygen × temperature interaction. The lack of interaction suggests that each factor influenced rates of oxygen uptake independently. This interpretation is indicated by the proportional nature of the data (Table 1). Flounder at 20 C-high oxygen consumed about twice as much oxygen as did flounder at 10 C-high oxygen. This same ratio is also evident at the reduced dissolved oxygen concentrations.

TABLE 1. Respiration rates of winter flounder simultaneously exposed to two levels of dissolved oxygen at each of two temperatures. Rates are the average oxygen consumption of three fish estimated three times over an 8-hr period.

		High oxygen			Low oxygen		
Test no.	Temp C (range)	mg O_2/liter (range)	Fish weight (range)	mg O_2/kg hr consumed	mg O_2/liter (range)	Fish weight (range)	mg O_2/kg hr consumed
I[a]	9.9 (9.0–10.5)	8.45 (8.40–8.50)	24.3 (20.0–29.7)	55	3.61 (3.53–3.65)	13.0 (11.5–14.1)	33
	21.5 (–)	6.48 (6.40–6.53)	15.8 (13.0–20.7)	91	3.73 (3.52–4.00)	23.1 (21.4–24.9)	72
II[a,b]	10.7 (10.5–11.0)	8.67 (8.65–8.70)	21.4 (14.0–32.3)	60	3.67 (3.55–3.80)	17.3 (13.9–19.1)	36
	21.0 (–)	6.25 (–)	24.2 (19.0–28.6)	127	3.12 (3.02–3.30)	16.8 (14.3–19.9)	78
III[a,b]	10.3 (10.0–11.0)	8.58 (8.55–8.65)	18.0 (14.4–21.8)	52	3.36 (3.20–3.47)	21.2 (14.8–30.2)	37
	20 (–)	6.27 (6.25–6.30)	23.6 (18.7–26.8)	74	2.83 (2.65–3.00)	22.6 (18.6–24.7)	61

[a]Effects of temperature significant ($P < .05$).
[b]Effects of dissolved oxygen significant ($P < .05$).

For data collected at the barge (Fig. 2), regression equations representing the rates of oxygen consumption of flounder of various weights exposed to different temperature–dissolved oxygen combinations include: $\log \hat{Y} = -0.707 + 0.792 \log X$ (20 C — 6.9 mg DO/liter), $\log \hat{Y} = -0.709 + 0.785 \log X$ (20 C — 4.3 mg DO/liter), $\log \hat{Y} = -0.979 + 0.720 \log X$ (10 C — 8.7 mg DO/liter), and $\log \hat{Y} = -1.033 + 0.746 \log X$ (10 C — 4.3 mg DO/liter). Included also are the sample standard deviations from regression and the sample standard deviations of the regression coefficients. In all instances, slope coefficients are less than 1.0, indicating small flounder consume more oxygen per unit weight than do large ones.

The respiration–weight coefficients found for winter flounder (about 0.79 at 20 C and about 0.73 at 10 C) are similar to those reported for other marine fishes. For example, weight–respiration coefficients of 0.74 for the spiny dogfish (*Squalus acanthias*), and 0.78 for the lingcod (*Ophiodon elongatus*) were reported by Pritchard et al. (1958). Also, the oxygen consumption rate of lemon (English) sole (*Parophrys vetulus*) increases with weight along a curve having a slope of 0.84 (Hickman 1959), and that of American plaice (*Hippoglossoides platessoides*) increased as weight increased on a slope of 0.72 (Edwards et al. 1969).

The expression "respiration dependence" describes a condition in which the respiration rate is dependent on the oxygen supply below a critical level (Fry 1947). This phenomenon has been observed in scup (*Stenotomus chrysops*), puffer (*Sphoeroides maculatus*), and oyster toadfish (*Opsanus tau*) (Hall 1929); and in brook trout (*Salvelinus fontinalis*), carp (*Cyprinus carpio*), and goldfish (*Carassius auratus*) (Beamish 1964). In the oyster toadfish, the relation of oxygen uptake to oxygen supply was found to be linear, and hyperbolic in the other five fishes. Our data indicate (Fig. 2) that at 10 and 20 C there are no differences in the respiration rates of flounder at near-satured oxygen levels and at 4.3 mg DO/liter. A comparison of results (Table 1 and Fig. 2) suggests that the respiratory metabolism of flounder is apparently independent of oxygen supply over a range of concentrations, and that the dissolved oxygen level at which the respiratory rate becomes related to oxygen supply is between 4.3 and 3.0 mg DO/liter.

The weight–respiration coefficients (Fig. 2), indicate that the rates of oxygen uptake increased with weight at a greater rate at 20 than at 10 C. Available field data indicate that large winter flounder are influenced more by temperature increases than are small ones (McCracken 1963). The current data (Fig. 2) confirm that larger winter flounder are not as readily adaptable to temperature increases because of their disproportionately greater oxygen demand at higher temperatures. It is likely that longer adaptation periods could modulate this requirement. However, this respiration pattern associated with temperature increases provides a

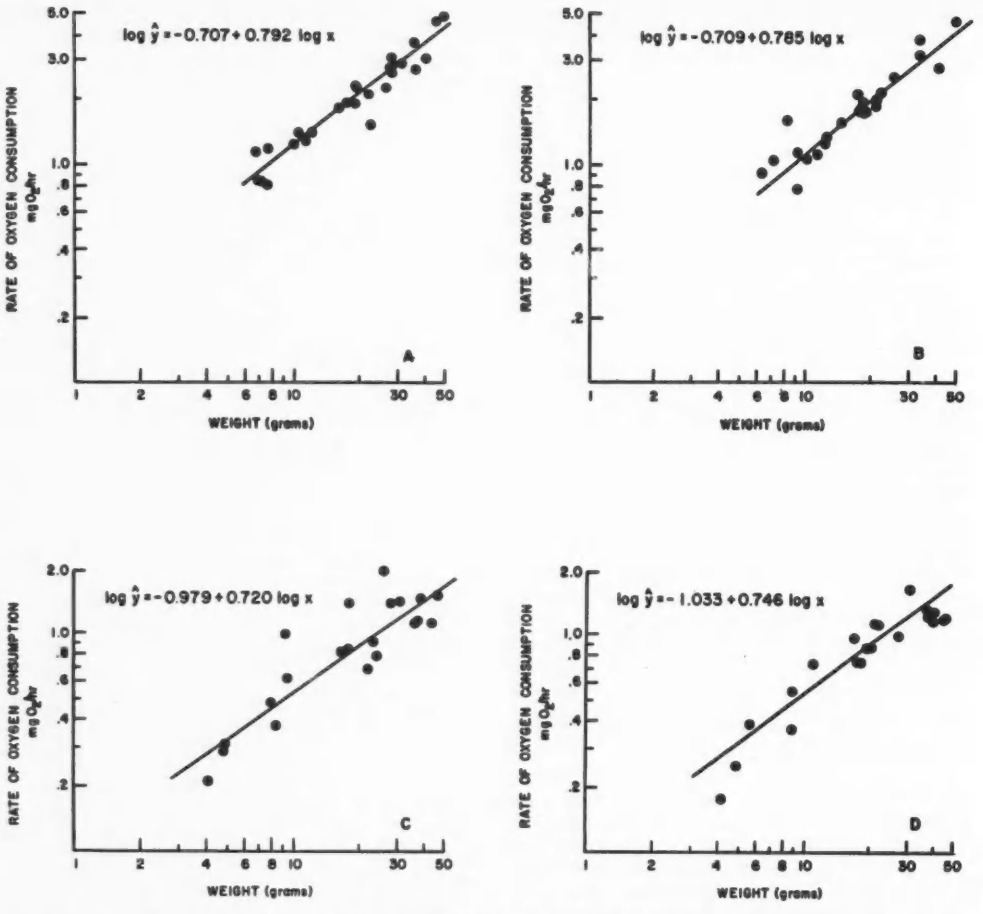
log ŷ = -0.707 + 0.792 log x
log ŷ = -0.709 + 0.785 log x
log ŷ = -0.979 + 0.720 log x
log ŷ = -1.033 + 0.746 log x
RATE OF OXYGEN CONSUMPTION
mg O2/hr
WEIGHT (grams)
A
B
C
D

FIG. 2. Rates of oxygen consumption of winter flounder of various weights exposed to different dissolved oxygen–temperature combinations. (A) 20 C — 6.9 mg DO/liter, standard deviation from regression 0.074, standard deviation of regression coefficient 0.032; (B) 20 C — 4.3 mg DO/liter, standard deviation from regression 0.086, standard deviation of regression coefficient 0.040; (C) 10 C — 8.7 mg DO/liter, standard deviation from regression 0.138, standard deviation of regression coefficient 0.053; (D) 10 C — 4.3 mg DO/liter, standard deviation from regression 0.098, standard deviation of regression coefficient 0.039.

possible explanation why large flounder are not common in waters having temperatures greater than 15 C (McCracken 1963).

No attempt was made to measure the activity of winter flounder within the respirometers. Data should therefore be considered as estimates at routine rates of oxygen consumption as defined by Beamish and Mookherjii (1964). Analysis of the data (Fig. 2) suggests a greater degree of variability in the respiration rates of flounder at 10 than at 20 C, as indicated by the standard deviations from regression. This difference can perhaps be attributed to a higher level of spontaneous activity among flounder at 10 C, a temperature that approaches the preferred temperature range (12–15 C) of winter flounder (McCracken 1963). In brook trout (Sullivan and Fisher (1947) and carp (Beamish and Mookherjii 1964), spontaneous activity increased as the temperature increased up to the region of preferred temperature, then decreased.

A comparison of the standard deviations from regression between the high and low oxygen levels at 10 and 20 C (Fig. 2) suggests differences in the respiratory responses of flounder that may be due to experimental error. However, in view of the significant effects on the respiration rates of slightly lower dissolved oxygen levels (Table 1), these differences may indicate the incipient stages of stress imposed by reduced dissolved oxygen. This latter interpretation corresponds to the concept of tolerance zones outlined by Fry (1947) to describe the effects of ranges of temperatures on fishes. It seems likely that this concept would also apply to the responses of fishes to various oxygen levels. Since the standard deviations from regression for the low oxygen data do not consistently increase or decrease relative to those for the high oxygen results, it may be that flounder respond differently to various dissolved-oxygen combinations.

The information obtained in this preliminary study provides some insight into the oxygen and temperature requirements of winter flounder. It is apparent, however, that additional information is necessary to elucidate the response patterns of flounder to various dissolved oxygen–temperature regimes. The results of this limited study could be used as a basis for such future investigations.

Acknowledgments — The authors sincerely thank Dr G. LaRoche for his continued encouragement, and Mr J. Mallett for his help with the computer analysis of the data, and Messrs B. Reynolds and W. Giles who helped collect and maintain the winter flounder.

AMERICAN PUBLIC HEALTH ASSOCIATION. 1965. Standard methods for the examination of water and waste water. 12th ed. APHA, New York, N.Y. 769 p.

BEAMISH, F. 1964. Respiration of fishes with special emphasis on standard oxygen consumption. III. Influence of oxygen. Can. J. Zool. 42: 355–366.

BEAMISH, F., AND P. MOOKHERJII. 1964. Respiration of fishes with special emphasis on standard oxygen consumption. I. Incidence of weight and temperature on respiration of goldfish, *Carassius auratus* L. Can. J. Zool. 42: 161–175.

BIGELOW, H., AND W. SCHROEDER. 1953. Fishes of the Gulf of Maine. U.S. Fish Wildl. Serv. Fish. Bull. 74: 1–577.

BRETT, J. R. 1970. Temperature, p. 515–560. *In* O. Kinne [ed.] Marine ecology. Wiley-Interscience, New York, N.Y.

EDWARDS, R., D. FINLAYSON, AND J. STEELE. 1969. The ecology of O-group plaice and common dabs in Loch Ewe. II. Experimental studies of metabolism. J. Exp. Mar. Biol. Ecol. 3: 1–17.

FRY, F. E. J. 1947. Effects of the environment on animal activity. Univ. Toronto Stud., Biol. Ser. No. 55, Publ. Ontario Fish. Res. Lab. No. 68: 62 p.

1957. The aquatic respiration of fish. *In* M. E. Brown [ed.] The physiology of fishes. Academic Press, Inc., New York, N.Y. 447 p.

HALL, F. G. 1929. The influence of varying oxygen tensions upon the rate of oxygen consumption in marine fishes. Amer. J. Physiol. 88: 212–218.

HICKMAN, C., JR. 1959. The osmoregulatory role of the thyroid gland in the starry flounder, *Platichthys stellatus*. Can. J. Zool. 37: 997–1060.

HILDEBRAND, J., AND W. SCHROEDER. 1928. Fishes of Chesapeake Bay. U.S. Bur. Fish. Bull. 43: 388 p.

MCCRACKEN, F. 1963. Seasonal movements of the winter flounder, *Pseudopleuronectes americanus* (Walbaum), on the Atlantic Coast, J. Fish. Res. Bd. Canada 20: 551–586.

OSTLE, B. 1964. Statistics on research. 2nd ed. Iowa State Univ. Press, Ames, Iowa. 585 p.

PRITCHARD, A., E. FLOREY, AND A. MARTIN. 1958. Relationship between metabolic rate and body size in an elasmobranch (*Squalus suckleyi*) and in a teleost (*Ophiodon elongatus*). J. Mar. Res. Sears Found. Mar. Res. 17: 403–411.

SULLIVAN, C., AND K. FISHER. 1947. Temperature selection and the effects of light and temperature on movements on fish. Fed. Proc. 6: 212–213.

TOPP, R. W. 1965. An annotated bibliography of the winter flounder, *Pseudopleuronectes americanus* (Walbaum). Mass. Dep. Natur. Resour. Div. Mar. Fish. Contribution No. 14: 30 p.

WHITWORTH, W. 1968. Effects of diurnal fluctuations of dissolved oxygen on the growth of brook trout. J. Fish. Res. Bd. Canada 25: 579–584.

WINBERG, G. G. 1956. Rate of metabolism and food requirements of fishes. (Transl. from Russian by Fish. Res. Board Can. Transl. Ser. No. 194, 1959)

Concentration of Bunker C Fuel Oil in the Waters of Chedabucto Bay, April 1971[1]

DONALD C. GORDON, JR. AND PAULA A. MICHALIK

Fisheries Research Board of Canada
Marine Ecology Laboratory, Bedford Institute, Dartmouth, N.S.

GORDON, D. C., JR., AND P. A. MICHALIK. 1971. Concentration of Bunker C fuel oil in the waters of Chedabucto Bay, April 1971. J. Fish. Res. Bd. Canada 28: 1912–1914.

The concentrations of Bunker C fuel oil in the waters of Chedabucto Bay in April 1971, 14 months after the *Arrow* disaster, were uniformly low, averaging 1.5 ppb. Comparison with other data indicates that concentrations in the bay have dropped more than an order of magnitude in the last year and now are at a level that is typical for the concentration of petroleum residues in the marine waters off Atlantic Canada. Although practically all of the Bunker C originating from the *Arrow* appears to be gone from the water column, oil coverage is still extensive in some inshore areas and considerable quantities of sedimented oil are probably present in the sediments of the bay.

GORDON, D. C., JR., AND P. A. MICHALIK. 1971. Concentration of Bunker C fuel oil in the waters of Chedabucto Bay, April 1971. J. Fish. Res. Bd. Canada 28: 1912–1914.

En avril 1971, soit 14 mois après le naufrage du pétrolier *Arrow*, la teneur en huile lourde de type C des eaux de la baie de Chedabucto était uniformément basse, soit de 1.5 ppb en moyenne. Par comparaison avec d'autres données, nous concluons que les concentrations de résidus de pétrole de la baie ont baissé à un niveau typique de la côte canadienne de l'Atlantique. Quoique l'huile lourde de l'*Arrow* semble presque complètement disparue de la colonne d'eau. Certaines portions du littoral sont encore recouvertes d'huile et de fortes quantités d'huile sédimentaire sont sans doute présentes sur le fond.

Received July 9, 1971

FOLLOWING the grounding of the Liberian tanker *Arrow* on February 4, 1970, most of her cargo of 108,000 barrels of Bunker C fuel oil was released into the waters of Chedabucto Bay, Nova Scotia. The details of this catastrophe, the ensuing clean-up operation, and subsequent scientific studies, as well as recommendations for dealing with future oil spills, have been reported by the Operation Oil Task Force (Anon. 1970).

Studies just a few weeks after the wreck (Forrester 1971) indicated that the oil was rapidly distributed throughout the water column of the bay in the form of particles ranging in size from 5 μ to 2 mm and in concentration from about 10 to 20 ppb. In early May 1970, Levy (1971) observed concentrations of particulate Bunker C in the water ranging from 16 to 40 ppb, and an equal or sometimes greater quantity of oil in a dissolved form.

To determine if Bunker C fuel oil originating from the *Arrow* disaster could still be detected in the water column of Chedabucto Bay, a return cruise was made 14 months after the incident, April 13–15, 1971, on the CNAV *Sackville*. The results are reported herein.

Methods — Water samples were collected at seven stations along the Nova Scotian coast between Halifax and Chedabucto Bay and at 15 stations in the bay and its outer reaches (Fig. 1).

The sampling and analytical procedures were patterned after those of Levy (1971) with minor modifications. Water samples were collected with 12-liter NMS plastic sampling bottles. After passing it through a piece of 160-μ mesh plankton net to remove large organisms, 2 liters of each sample were immediately placed in a 4-liter Pyrex separatory funnel and extracted twice with 40 ml of spectrophotometric grade carbon tetrachloride. Each extraction involved vigorous shaking for 30 sec, separation for 10 min, and removal of the carbon tetrachloride phase. The extracts were stored in glass bottles until analysis ashore. There was no attempt to separate the particulate from the dissolved oil as done by Levy (1971), and therefore the results indicate total oil concentrations.

In the laboratory, the carbon tetrachloride was evaporated on a hot plate and the residue (never visible) was taken up in 10 ml of spectrophotometric grade hexane. The aromatic hydrocarbon content of each sample was determined using a Perkin-Elmer Model MPF-2A Fluorescence Spectrophotometer. Samples were excited at 330 nm and the fluorescence peak

[1]Bedford Institute Contribution No. 277.

Printed in Canada (J2231)

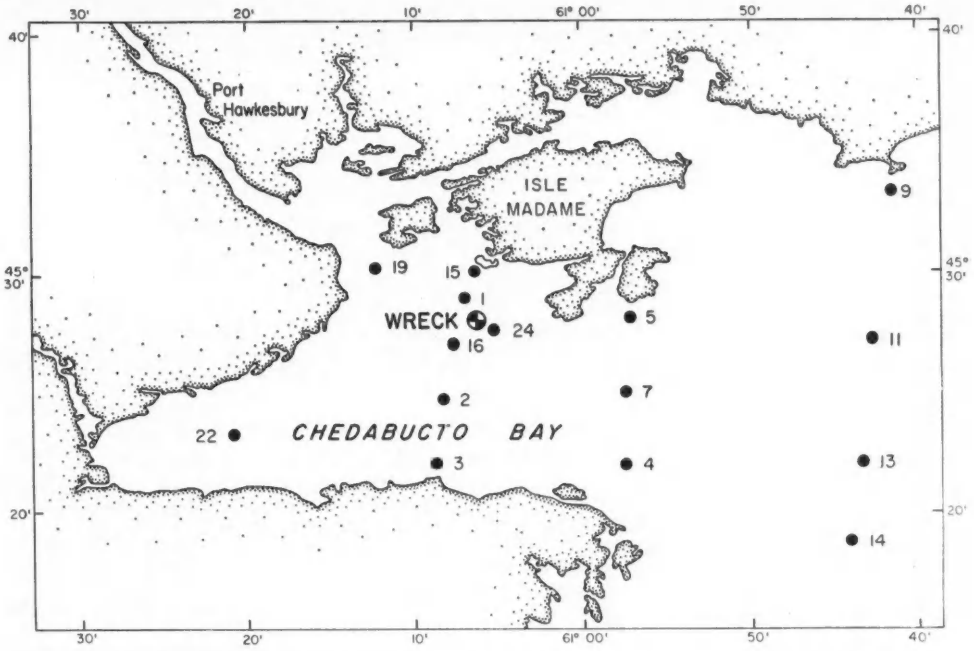

FIG. 1. Chedabucto Bay showing site of *Arrow* wreck and location of stations occupied April 14–15, 1971.

at 360 nm measured. After subtracting the blank caused by impurities in the reagents (equivalent to about 2 ppb), the height of this peak was related to concentration by calibrating with Bunker C retrieved from the hold of the *Arrow*. The calibration was repeated three times over the range of 0–16 ppb and was linear. The standard deviation of replicate analyses of the same water sample ($\bar{X} = 2.0$ ppb) was 0.4 ppb.

This fluorescence method is not as specific as gas chromatographic techniques, such as used by Blumer et al. (1970). It detects all aromatic hydrocarbons present in a water sample, including those that occur naturally and those originating from oil contamination not caused by the *Arrow* disaster. An estimate of the amount of fluorescence due to naturally occurring aromatics (natural background) was obtained by analyzing water samples from two relatively unpolluted Nova Scotian coastal embayments: St Margaret's Bay and Petpeswick Inlet. This natural background averaged 0.3 ppb and was subtracted from all values. Since it is impossible to determine the amount of fluorescence that might be caused by the presence of other oils, the concentrations reported below represent the *maximum* possible concentrations of Bunker C fuel oil originating from the *Arrow*.

Results and discussion — The concentrations of Bunker C fuel oil in Chedabucto Bay and its outer reaches at the time of sampling were low and uniform (Table 1), averaging 1.5 ppb. There were no apparent variations in different parts of the bay, including three stations within a mile of the wreck. Although not significant, the data indicate increasing concentrations with depth, just the opposite observed by Levy (1971) and Forrester (1971) a year earlier. Concentrations along the Nova Scotian coast between Halifax and Chedabucto Bay were also uniformly low (Table 1), averaging 1.4 ppb.

The only visible evidence of oil in the bay was a few lumps of tar floating on the sea surface between stations 9 and 11 (Fig. 1). No oil particles were visible on the 160-μ plankton net used for prefiltering.

Comparing these data with those of Levy (1971), which were obtained using identical analytical methods, it is obvious that the concentrations of Bunker C in the water column of Chedabucto Bay and its outer reaches have dropped by more than an order of magnitude in the last year. Concentrations now observed are typical of those reported for the Scotian Shelf and the Gulf of St. Lawrence (Levy 1971) and much lower than those observed in Halifax Harbour, June–August 1971 (1.9–71.7 ppb). This

TABLE 1. Summary of Bunker C fuel oil concentrations observed April 13–15, 1971.

Location	Depth (*m*)	*n*	Mean total concn (*ppb*)	Range
Chedabucto Bay and outer reaches	5	15	1.2	0.0–2.7
	6–25	11	1.4	0.0–4.0
	26–50	11	1.8	0.7–3.4
	>51	3	1 9	1.5–2.5
	All	40	1.5	0.0–4.0
N.S. coast between Halifax and Chedabucto Bay	5	7	1.4	0.5–2.6

indicates that little, if any, of the oil released from the *Arrow* remains in the water column of the bay.

This decrease in the Bunker C concentration is probably due to several processes working simultaneously. The most important of these appears to be water exchange since the Bay has undoubtedly been flushed many times between the disaster and the measurements reported here. Other processes that could remove Bunker C from the water column are direct sedimentation of oil particles, sedimentation after incorporation into fecal pellets (Conover 1971), and attachment to suspended solids, and probably an unknown amount of microbial decomposition.

The results of this study do not indicate that all the Bunker C fuel oil originating from the wreck of the *Arrow* has been removed from the bay or that it no longer constitutes a threat to the marine flora and fauna in the area. They only demonstrate that as of April 1971, 14 months after the disaster, only trace amounts of oil were found in the water column. Scarratt (MS 1971) reports the continued presence of oil in sediments and invertebrate organisms at selected stations in the sublittoral zone around the bay, and Thomas (MS 1971) reports that extensive oil coverage persists in some intertidal and lagoonal areas. Judging from the fecal pellet observations of Conover (1971), considerable quantities of Bunker C are probably also present in sediments in the deeper parts of the bay.

Acknowledgments — We thank Dr E. M. Levy for his advice while developing the analytical methods, and Mr P. Vass for his assistance in collecting the samples.

ANON. 1970. Report of the Task Force — Operation Oil to the Minister of Transport. Ministry of Transport, Ottawa, Ont. 3 vol.

BLUMER, M., G. SOUZA, AND J. SASS. 1970. Hydrocarbon pollution of edible shellfish by an oil spill. Mar. Biol. 5: 195–202.

CONOVER, R. J. 1971. Some relationships between zooplankton and Bunker C grade fuel oil in Chedabucto Bay following the wreck of the tanker *Arrow*. J. Fish. Res. Bd. Canada 28: 1327–1330.

FORRESTER, W. D. 1971. Distribution of suspended oil particles following the grounding of the tanker *Arrow*. J. Mar. Res. 29: 151–170.

LEVY, E. M. 1971. The presence of petroleum residues off the east coast of Nova Scotia, in the Gulf of St. Lawrence, and the St. Lawrence River. Water Res. 5: 723–733.

SCARRATT, D. J. MS 1971. Incidence of Bunker C oil in common benthic animals. Paper presented at the Oil Pollution Workshop, August 26–27, 1971, Nova Scotia Technical College, Halifax, N.S.

THOMAS, M. L. MS 1971. Effects of oil on intertidal and lagoonal biota in Chedabucto Bay, Nova Scotia. Paper presented at the Oil Pollution Workshop, August 26–27, 1971, Nova Scotia Technical College, Halifax, N.S.

Fertilization of Steelhead Trout (*Salmo gairdneri*) Eggs With Cryo-preserved Sperm[1]

A. G. Ott and H. F. Horton

Department of Fisheries and Wildlife
Oregon State University, Corvallis, Oreg., USA

Ott, A. G., and H. F. Horton. 1971. Fertilization of steelhead trout (*Salmo gairdneri*) eggs with cryo-preserved sperm. J. Fish. Res. Bd. Canada 28: 1915–1918.

The average percent fertilization of fresh steelhead trout (*Salmo gairdneri*) ova inseminated with cryo-preserved sperm was 59 in 90 tests. Sodium bicarbonate, lecithin, and mannitol at 750, 750, and 250 mg/100 ml, respectively, were included in the extender. The most effective concentration of dimethyl sulfoxide in the extender was 12% (v/v). Significant differences in percent of fresh ova fertilized with cryo-preserved sperm were attributed to both parents.

Ott, A. G., and H. F. Horton. 1971. Fertilization of steelhead trout (*Salmo gairdneri*) eggs with cryo-preserved sperm. J. Fish. Res. Bd. Canada 28: 1915–1918.

Au cours de 90 essais de fécondation d'œufs frais de truites steelhead (*Salmo gairdneri*) par du sperme conservé sous réfrigération, le taux de fécondation a été de 59%. Du bicarbonate de sodium, de la lécithine et du mannitol, à des concentrations respectives de 750, 750 et 250 mg/100 ml, furent ajoutés au diluant. La concentration la plus efficace de diméthyl sulfoxyde dans le diluant a été de 12% (v/v). Des différences significatives dans les taux de fécondation ont été attribuées à l'un ou l'autre des parents.

Received May 25, 1971

This is a report on development of an improved extender for the cryo-preservation of steelhead trout (*Salmo gairdneri*) sperm, and on the fertilizing capabilities of the frozen–thawed sperm when mixed with fresh eggs. Developments in the cryo-preservation of viable salmonid sperm have been reported recently by Hoyle and Idler (1968), Truscott and Idler (1969), Ott and Horton (1971), and Graybill and Horton (1969). In the work by the last two authors, the maximum percent fertilization of fresh steelhead trout eggs inseminated with frozen–thawed sperm was 18. The techniques described here resulted in more than a fourfold increase in maximum percent fertilization. Preliminary results of this research were reported by Ott and Horton (MS 1969).

Methods and procedure—Sperm samples from steelhead trout were collected at the Eagle Creek National Fish Hatchery near Estacada, Oregon, during the spring of 1969. Mature trout were anesthetized with tricaine methanesulfonate (M.S. 222), rinsed with water, and wiped dry around the genital region with absorbent paper. Manual pressure to the abdominal region was used to express semen into 2-oz glass jars. These jars were placed in an insulated portable cooler containing 1-inch of water from the holding pond. After all samples were collected, ice was added to the water bath and 30 min was allowed for the sperm samples to cool to approximately 5 C.

Extenders (solutions of salts used to dilute and maintain viability of sperm during refrigeration) contained a life protector (organic compound used to protect sperm during the freeze–thaw process) and were prepared within 24 hr of use. Containers of these solutions were placed in the water bath with the undiluted sperm samples, so that the temperatures of sperm and extender were equal at the time of dilution.

In the sperm-freezing procedure, a 9-ml aliquot of the extender was transferred into a cooled jar, and 1 ml of undiluted semen added. Subsamples (1-ml) of this solution were pipetted immediately into 1-ml ampoules, and the unsealed ampoules placed in the vapor (–179 C) above the surface of the liquid nitrogen (–196 C). Temperature reduction of the solutions occurred at a rate of –30 C/min (Graybill and Horton 1969). After 5 min in liquid nitrogen (LN_2) vapor, the unsealed ampoules of semen were lowered into the LN_2 refrigerator and stored for further analysis. A description of the cryogenic equipment used was given by Graybill and Horton (1969).

In preliminary experiments, extenders containing selected concentrations of the chemical components were prepared and tested. Sperm was collected from two or three males, subdivided into 1-ml aliquots, diluted with each of the extenders, and frozen. As general indicators of viability, motility estimates of sperm thawed in a 4 C

[1]Technical Paper No. 3099, Oregon Agricultural Experiment Station.

Printed in Canada (J2178)

water bath were made by microscopic examination. Selection of the preferred concentration of each chemical was based on these percent motility estimates. The value of using estimates of percent motile sperm as the criterion for selecting the best concentration of a chemical tested was indicated by Ott and Horton (1971), the advantage being to decrease the time required to evaluate the effect of a change in the chemical composition of an extender. This procedure was useful in evaluating treatments (chemicals) within an experiment, but we do not recommend comparing percents of motile sperm between experiments. In this manner, sodium bicarbonate, lecithin, mannitol, and dimethyl sulfoxide (DMSO) were tested until an improved extender and protector combination was developed.

Final evaluation of the improved extender was based on results of fertilization experiments. Sperm samples were collected from 10 fish, diluted with the extender containing DMSO (the life protector), and frozen in LN_2 for 7 days. Three females were killed and bled by cutting the caudal artery, and the eggs of each divided into 36 groups. After 7 days the frozen sperm samples were thawed in hatchery water (5–9 C), and 1-ml aliquots from each male were mixed with a group of eggs from each female (three replicates). For controls, three groups of eggs from each female were fertilized with fresh sperm from the same male, and three additional groups were not fertilized as a check for parthenogenic development or chance fertilization via the hatchery water supply. Each of the 108 groups of eggs was placed in an individual container in a hatchery trough and incubated 14 days. Eggs were then placed in Carnoy's solution (three volumes 100% ethanol to one volume glacial acetic acid), and the percent of eggs with visible embryonic development determined.

Results and discussion — An improved fish sperm extender (Ext 164, Table 1) was developed on the basis of percent motility estimates in which the most promising concentrations for sodium bicarbonate, lecithin, and mannitol were 750, 750, and 250 mg/100 ml, respectively (Table 2). In these tests, Ext 48 (Table 1), used with limited success with steelhead trout by Graybill and Horton (1969), served initially as the control solution.

When samples of sperm were diluted with Ext 164 containing 4, 8, and 12 %(v/v) DMSO, percent motility estimates were highest at 12% DMSO, the means and (in parentheses) ranges in six tests being:

DMSO (%v/v)	4	8	12
Motility (%)	09 (00–10)	20 (10–30)	45 (40–50)

It appears that each species of fish may have different requirements for a life-protective agent for frozen and thawed sperm. Blaxter (1953) and Mounib et al. (1968) successfully used glycerol with Pacific herring (*Clupea harengus pallasi*) and Atlantic cod (*Gadus morhua*) sperm, and Hoyle and Idler (1968) and Truscott and Idler (1969) achieved limited success using ethylene glycol and propylene glycol, respectively, with Atlantic salmon (*Salmo salar*) sperm. In experiments with coho salmon (*Oncorhynchus kisutch*) sperm, Ott and Horton (1971) found DMSO superior to ethylene glycol, and glycerol, sucrose, ethanol, and polyvinylpyrrolidone were unsatisfactory.

The average percent fertilization of fresh ova inseminated with cryo-preserved sperm diluted with Ext 164 (containing 12% DMSO) was 59 (Table 3). These 90 observations were distinguished by their consistency, whereas data from our

TABLE 1. Concentrations (mg/100 ml)[a] of the chemicals in the extenders tested.

Extender no.	NaCl	KCl	$CaCl_2 \cdot 2H_2O$	$NaHCO_3$	$NaH_2PO_4 \cdot H_2O$	$MgSO_4 \cdot 7H_2O$	Fructose	Lecithin	Mannitol
48	730	38	23	100	41	23	100	500	–
129	730	38	23	500	41	23	100	500	–
130	730	38	23	1000	41	23	100	500	–
150	730	38	23	–	41	23	100	500	–
155	730	38	23	250	41	23	100	500	–
156	730	38	23	750	41	23	100	500	–
157	730	38	23	750	41	23	100	–	–
158	730	38	23	750	41	23	100	250	–
160	730	38	23	750	41	23	100	750	–
161	730	38	23	750	41	23	100	1000	–
162	730	38	23	750	41	23	100	1500	–
163	730	38	23	750	41	23	100	750	100
164	730	38	23	750	41	23	100	750	250
165	730	38	23	750	41	23	100	750	500

[a]Milligrams of solute per 100 ml total solution.

previous fertilization experiments ranged from zero to 76% (Graybill and Horton 1969; Ott and Horton 1971). The variation in average fertility between males and between females was significant ($P < 0.05$). One possible reason for the variability among males was their being at different stages of sexual maturity. Experimental error may also have contributed to the variability, although we attempted to standardize all of our procedures. The average percent fertilization of controls (eggs of each female mixed with fresh sperm from a single male) varied but 1%, indicating that differences between females probably were due to variation in the experimental procedure or a differential response to frozen–thawed sperm.

In the final experiment, the number of eggs per experimental unit was increased (volume of sperm per experimental unit was the same as before), but the percent of fresh ova fertilized did not change. In three tests with small numbers of eggs (49–56) and in eight tests with larger numbers of eggs (102–187), fertilization averaged 58% in both groups.

A possible reason the percent fertilization was not higher among all the experimental units was that dead and agglutinated spermatozoa may have obstructed vigorous spermatozoa from entering the micropyle, which is too narrow to allow more than one sperm to pass at a time (Blaxter 1969). In this case, percent fertilization would not be expected to change with an increase in egg number, but would simply reflect the fraction of spermatozoa not weakened by the freeze–thaw process. As recommended by Truscott and Idler (1969), a method of excluding the dead and weakened sperm should be found.

TABLE 2. Percent motilities of steelhead trout sperm, frozen 3 days in LN_2 and thawed in a 4 C water bath, when diluted with various extenders (Table 1) to which three chemicals were added in several concentrations.

Chemical concn (*mg/100 ml*)	Extender no.	Motility (%)
	Sodium bicarbonate	
0	150	10(10–10)[a]
100	48	11(10–20)
250	155	13(10–20)
500	129	33(20–40)
750	156	43(20–70)
1000	130	26(20–40)
	Lecithin	
0	157	11(00–20)
250	158	11(10–20)
500	156	21(10–40)
750	160	28(20–40)
1000	161	23(20–30)
1500	162	23(20–30)
	Mannitol	
0	160	25(20–30)
100	163	25(20–30)
250	164	40(30–50)
500	165	15(10–20)

[a]Mean and range; eight tests.

TABLE 3. Percentages of eggs from each of three females that were fertilized when inseminated with sperm, from each of 10 males, frozen 7 days in liquid nitrogen (–196 C).

	Female									
Male no.	1				2			3		Avg
351	68	32	61	68	53	74	64	69	62	61
352	45	38	35	71	79	51	55	30	58	51
353	49	20	78	79	49	84	70	31	70	59
354	79	89	87	76	86	86	79	80	83	82
355	67	47	64	87	67	73	75	34	72	65
356	55	84	51	83	70	73	63	75	63	69
357	41	51	17	50	62	69	41	44	46	47
358	38	51	49	42	61	48	52	27	52	47
359	17	40	52	51	68	58	55	59	61	51
360	51	37	58	77	64	82	70	56	50	61
avg		52			68			58		59
Control[a]		96			97			97		
Control[b]		0			0			0		

[a]Eggs with fresh sperm.
[b]Eggs with no sperm.

Acknowledgments — This investigation was supported in part by funds from the U.S. Department of Commerce, National Marine Fisheries Service (Contract No. 14-17-0001-1938). We appreciate the use of facilities and helpful suggestions provided by Mr R. Bigej and his assistants at the Eagle Creek National Fish Hatchery. Dr J. McIntyre, Assistant Leader, Oregon Cooperative Fishery Unit, and Mr D. Shumway, Associate Professor of Fisheries, Oregon State University, reviewed the manuscript.

BLAXTER, J. H. S. 1953. Sperm storage and cross-fertilization of spring and autumn spawning herring. Nature 172: 1189–1190.

BLAXTER, J. H. S. 1969. Development: eggs and larvae, p. 177–252. *In* W. S. Hoar and D. J. Randall [ed.] Fish physiology. Vol. III. Academic Press, Inc., New York and London.

GRAYBILL, J. R., AND H. F. HORTON. 1969. Limited fertilization of steelhead trout eggs with cryo-preserved sperm. J. Fish. Res. Bd. Canada 26: 1400–1404.

HOYLE, R. J., AND D. R. IDLER. 1968. Preliminary results in the fertilization of eggs with frozen sperm of Atlantic salmon (*Salmo salar*). J. Fish. Res. Bd. Canada 25: 1295–1297.

MOUNIB, M. S., P. C. HWANG, AND D. R. IDLER. 1968. Cryogenic preservation of Atlantic cod (*Gadus morhua*) sperm. J. Fish. Res. Bd. Canada 25: 2623–2632.

OTT, A. G., AND H. F. HORTON. MS 1969. Developments in cryo-preservation of salmonid sperm. Proc. Annu. Conf. West. Ass. Game Fish. Comm. 49: 249–250.

1971. Fertilization of chinook and coho salmon eggs with cryo-preserved sperm. J. Fish. Res. Bd. Canada 28: 745–748.

TRUSCOTT, B., AND D. R. IDLER. 1969. An improved extender for freezing Atlantic salmon spermatozoa. J. Fish. Res. Bd. Canada 26: 3254–3258.

Abnormal Body Curvatures of Rainbow Trout (*Salmo gairdneri*) Inbred Fry

DAG AULSTAD AND ARNE KITTELSEN

The Agricultural College of Norway
Institute of Animal Genetics and Breeding, Vollebekk, Norway

AULSTAD, D., AND A. KITTELSEN. 1971. Abnormal body curvatures of rainbow trout (*Salmo gairdneri*) inbred fry. J. Fish. Res. Bd. Canada 28: 1918–1920.

In an inbreeding experiment with rainbow trout (*Salmo gairdneri*), a special type of deformed fry was found. The deformity appeared after one generation of fullsib mating in one of nine fullsib groups. The deformed fry were observed soon after the resorption of the yolk sac and showed different forms of body curvatures. The deformity was lethal. Significant differences between inbred groups and the noninbred control groups indicate that the deformity is at least partly heritable.

AULSTAD, D., AND A. KITTELSEN. 1971. Abnormal body curvatures of rainbow trout (*Salmo gairdneri*) inbred fry. J. Fish. Res. Bd. Canada 28: 1918–1920.

Une expérience de croisements consanguins avec des truites arc-en-ciel (*Salmo gairdneri*) a abouti à un type particulier d'alevins difformes. La difformité est apparue, après une génération, dans un des neuf groupes de croisements entre poissons issus de mêmes parents. Les alevins difformes, présentant diverses courbatures du corps, ont été remarqués peu après la résorption du sac vitellin. La difformité est léthale. Les différences significatives entre groupes de croisements consanguins et groupes témoins non consanguins témoignent du caractère au moins partiellement héréditaire de la difformité.

Received April 5, 1971

A number of different deformities, including abnormal curvatures, are known in fish. Abnormal body curvatures can be either deformities of the vertebral column or the result of abnormal muscle contractions.

Different factors may cause these deformities. Schäperclaus (1954) mentions that different forms of abnormal skeletal structures, such as shortening and curvatures of the vertebral column, may be caused by hereditary factors. He also describes a number of environmental factors that contribute to the same deformities, such as infections or other

Printed in Canada (J2115)

undesirable environmental influences in earlier stages in life. Regarding rainbow trout (*Salmo gairdneri*), Calaprice (1969) suggests a hereditary basis for different deformities.

Certain types of these deformities are observed at an early stage. Christensen (1966) suggests that environmental factors, such as low oxygen content in the water early in the hatching period, may give abnormal body curvatures on newly hatched fry.

In the spring of 1970, an inbreeding experiment was started with rainbow trout at the Institute of Animal Genetics and Breeding at the Agricultural College of Norway. Fullsibs were mated within nine different sib groups. The eggs from each female were divided into three portions, two of which were fertilized by semen from two fullsib males. The third portion was fertilized by an unrelated male for control. Some deviations from this design had to be made because of a low number of eggs from a few of the females.

The material consisted of 53 inbreeding and 19 control groups. Hatching started on May 26, and feeding of the fry started on June 8. During both hatching of the eggs and feeding of the fry, uniform environments were aimed at. Before the start of feeding, the fry groups were transferred from the hatchery to 1-m^2 basins, all located in one shed. A maximum of 500 individuals from each group were transferred to the basins.

The inbreeding groups from parent group no. 2 showed frequent occurrences of deformed fry. This deformity did not appear in the other groups. The fact that the different inbreeding and control groups were placed at random both in the hatchery and in the shed should insure against any possible systematic environmental differences between inbreeding and control groups.

The deformity was lethal and appeared immediately after absorption of the yolk sac. As may be seen (Fig. 1), the deformity consisted of different forms of body curvatures. At this stage the ossication of the vertebral column had not started and, therefore, any possible curvatures in it could not be detected by X-rays. The behaviour of the fry may suggest the deformity to be of a neuromuscular character. Before they died, the abnormal fry were observed lying quietly on the bottom and then whirling around violently for a few seconds. The form of the curvatures affected the movement, e.g., an S-form gave an S-like rotation. None of the deformed fry showed any indication of food consumption. Similar types of deformities are observed in many hatcheries; that described here partly shows the same pattern as one described by Rucker et al. (1970).

Table 1 shows the occurrence of this deformity of fry during the first few days after the start of feeding for all groups from parent group 2, as well as mortality of eggs and fry in this group, and the average for all inbreeding and control groups. For group 2, A, B, and C denote the different females, and roman numerals denote the different males.

The comparatively high total mortality of the eggs probably is due to the high water temperature during hatching, with maximum about 13 C.

A chi-square test showed a significantly greater frequency ($P < 0.001$) of abnormal fry ($\chi^2 = 116.707$), mortality of the eggs ($\chi^2 = 459.102$), and mortality of the fry ($\chi^2 = 115.315$) when the combined inbreeding groups were compared with the combined control groups. There was also a great vari-

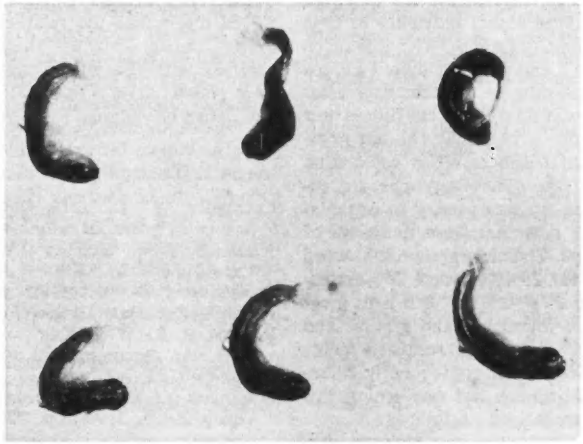

FIG. 1. Fry of rainbow trout showing abnormal body curvatures.

TABLE 1. Frequencies of deformity of fry in inbred and control groups, and mortality of eggs and fry.

	Eggs		Fry		
Parent group 2	Total no.	% dead	Total no.	% deformed	% dead
Inbred:					
2A×2II	1319	58.3	500	7.0	10.8
2A×2III	1117	53.4	500	15.2	16.2
2B×2II	1040	38.5	500	12.8	12.8
2B×2III	1078	24.9	460	16.7	20.0
2C×2I	1170	73.5	285	1.8	3.2
Control:					
2A×5III	994	30.1	500	0.6	1.6
2B×11IV	590	8.5	500	0.0	1.0
Sum, inbred (2)	5724	52.3	2245	11.4	13.4
Sum, control (2)	1584	22.0	1000	0.3	1.3
Inbred total	57477	32.86	27100	–	4.75
Control total	18489	22.24	11650	–	2.61

ance between all seven groups ($\chi^2 = 194.8297$, $P < 0.001$) and between the different mating combinations within sibgroup 2 ($\chi^2 = 56.723$, $P < 0.001$). This pattern also persists when excluding group 2C×2I, which differs most from the other groups.

The significant difference between inbred and control groups shows that the deformity is at least partly heritable. The genetic background for it is not clear. When the deformity is caused by a recessive factor in one locus, we should obtain 25% deformed individuals if there is complete penetration and if the parents are heterozygotes.

The factor (or factors) that causes the observed deformity may also cause higher mortality of eggs and of fry not showing deformity. The difference between inbred group 2 and all other inbred groups in mortality from spawning to the first days after the start of feeding was 25.4%. A chi-square test may be used to test this hypothesis: The egg number was used as total number. When calculating the total mortality of the different groups, the total number of hatched fry was used. The observations were taken as a deviation from the mean of all other inbred groups. The chi-square test showed that the probability for 25.4%, when 25% is expected, is in the area $P = 0.5$–0.7. But here great heterogeneity was also found between groups, and the hypothesis that it is a single recessive factor with complete penetration can consequently be rejected. The actual chi-square test concerning this mortality may be summarized as follows:

	χ^2	df	P
Total	327.263	5	<0.001
Total deviation from 3:1	0.183	1	0.50–0.70
Heterogeneity	327.060	4	0.001

Occurrences of deformities may result from different causes. A single recessive factor with incomplete penetration is not impossible. Also, many genes from different loci may be involved, with or without interaction. Interaction between the environment and the gene configuration could also be involved. In this instance, such an interaction would mean that the relatively unfavourable conditions during hatching (high water temperature) together with the groups' gene configuration may have caused deformities that would not occur under better conditions.

CALAPRICE, J. R. 1969. Production and genetic factors in managed salmonid populations. Symp. Salmon Trout Streams, Univ. British Columbia, Vancouver, B.C. 388 p.

CHRISTENSEN, N. O. 1966. Fiskesykdomme. Medlemsbl. Den Dan. Dyrlaegeforen. 49: 451–546.

RUCKER, R. R., W. T. YASUTAKE, AND G. WEDEMEYER. 1970. An obscure disease of rainbow trout. Progr. Fish-Cult. 32: 3–8.

SCHÄPERCLAUS, W. 1954. Fishkrankheiten. Akademie-Verlag, Berlin, 3, Auflage. 708 p.

A Record of Pacific Herring (*Clupea harengus pallasi*) Feeding on Juvenile Chinook Salmon (*Oncorhynchus tshawytscha*) in a British Columbia Estuary

JUN ITO[1] AND R. R. PARKER

Fisheries Research Board of Canada
Biological Station, Nanaimo, B.C.

ITO, J., AND R. R. PARKER. 1971. A record of Pacific herring (*Clupea harengus pallasi*) feeding on juvenile chinook salmon (*Oncorhynchus tshawytscha*) in a British Columbia estuary. J. Fish. Res. Bd. Canada 28: 1921.

An occurrence of Pacific herring (*Clupea harengus pallasi*) predation on juvenile chinook salmon (*Oncorhynchus tshawytscha*) is described. This is the first recorded incidence of this particular predator–prey relation.

ITO, J., AND R. R. PARKER. 1971. A record of Pacific herring (*Clupea harengus pallasi*) feeding on juvenile chinook salmon (*Oncorhynchus tshawytscha*) in a British Columbia estuary. J. Fish. Res. Bd. Canada 28: 1921.

Les auteurs décrivent un cas de prédation de saumons chinook (*Oncorhynchus tshawytscha*) juvéniles par le hareng pacifique (*Clupea harengus pallasi*). C'est la première mention d'une relation prédateur–proie de cette nature.

Received July 5, 1971

The distribution of Pacific herring (*Clupea harengus pallasi*) and the several members of Pacific salmon (*Oncorhynchus*) nearly coincide on the North Pacific rim. As salmon are anadromous and herring occupy the near-shore areas, one might expect a predator–prey relation involving these species. In fact, herring form a major item of the diet of chinook (*O. tshawytscha*) and coho (*O. kisutch*) salmon (Prakash 1962; Pritchard and Tester 1944). The diet of herring has been examined by Motoda and Takeuchi (1949), and by Wailes (1935), but no observation of herring feeding on juvenile salmon was recorded until Thorsteinson (1962) reported herring feeding on pink (*O. gorbuscha*) fry in an Alaskan estuary. Our finding of chinook fry in the stomachs of two herring taken from a British Columbia estuary appears to be a first-recorded incidence.

Two large herring were captured in Alberni Inlet with a two-boat midwater trawl on June 4, 1971, about 3 km from the Somass River mouth. One was 226 mm and the other 221 mm fork length, and both were, according to scale analysis, in their 4th year of life (3+). One herring stomach contained 16 and the other 18 chinook salmon fry. Although it was impossible to accurately measure fork lengths of the partially digested chinook, measurements taken indicated a range of size from 33 mm to 43 mm (mean 37.6 mm). Considering this size distribution, the chinook are considered to have fed not more than a week in the estuarine waters of the inlet.

This record, added to Thorsteinson's (1962), indicates that Pacific salmon, which commonly enter the sea as fry, e.g., pink, chum (*O. keta*), chinook, and to a lesser extent coho, may be subject to a short but intensive period of predation by large individuals of herring populations inhabiting the estuarine waters.

Acknowledgments — The authors acknowledge the assistance of Mrs B. Kask and Mr A. Solmie, who identified and verified the salmon species, and Mr R. S. Isaacson, who estimated the age of the herring.

MOTODA, S., AND I. TAKEUCHI. 1949. The food of spring herring in Hokkaido in 1948. J. Hokkaido Fish. Exp. Sta. 1: 32–44.

PRAKASH, A. 1962. Seasonal changes in feeding of coho and chinook (spring) salmon in southern British Columbia waters. J. Fish. Res. Bd. Canada 19: 851–866.

PRITCHARD, A. L., AND A. L. TESTER. 1944. Food of the spring and coho salmon in British Columbia. Fish. Res. Board Can. Bull. 65: 1–23.

THORSTEINSON, F. V. 1962. Herring predation on pink salmon fry in a southeastern Alaska estuary. Trans. Amer. Fish. Soc. 91: 321–323.

WAILES, G. H. 1935. Food of *Clupea pallasii* in Southern British Columbia waters. J. Biol. Bd. Canada 1: 477–486.

[1]On a temporary Canadian–Japanese scientist exchange. Home address: Far Seas Fisheries Research Laboratory, 1000 Orido Shimizu, Shizuoka, Japan.

Printed in Canada (J2224)

A Sculpin (*Icelus spiniger*) New to the Coastal Waters of British Columbia

W. E. BARRACLOUGH

Fisheries Research Board of Canada
Biological Station, Nanaimo, B.C.

BARRACLOUGH, W. E. 1971. A sculpin (*Icelus spiniger*) new to the coastal waters of British Columbia. J. Fish. Res. Bd. Canada 28: 1922–1924.

Icelus spiniger Gilbert was collected at two locations off the coast of British Columbia. These are the most southerly records, as well as the first records of *I. spiniger* in British Columbia.

BARRACLOUGH, W. E. 1971. A sculpin (*Icelus spiniger*) new to the coastal waters of British Columbia. J. Fish. Res. Bd. Canada 28: 1922–1924.

Icelus spiniger Gilbert a été capturé à deux endroits de la côte de la Colombie britannique. En plus d'une première mention pour la Colombie britannique, ces captures constituent une extension d'aire de l'espèce vers le sud.

Received April 19, 1971

A small "thorny sculpin," *Icelus spiniger* Gilbert (Fig. 1) was identified in a collection of fishes made during a shrimp- and prawn-prospecting survey off the British Columbia coast during the summer and fall months of 1954. The specimen was caught in a shrimp trawl, tow No. 172, at the head of Alice Arm on the west coast of Vancouver Island, B.C., at 50°28′N, 127°29′20″W, on mud bottom at a depth of 104–113 m on September 26, 1954 (Butler and Dubokovic 1955). This specimen, measuring 81 mm total length, 65 mm standard length, has been deposited in the collection of fishes at the University of British Columbia and bears the catalogue number BC 65-133.

A second specimen was caught in a 4-ft naturalist drag on the *G. B. Reed* at station no. 77, about 40 miles northwest of Cape Knox, Queen Charlotte Islands, at 54°37′N, 133°55′W in 229 m during August 1965 (Bernard et al. MS 1967). It measured 99 mm total length, 82 mm standard length, and is now deposited in the National Museum of Canada with the number NMC 65-330.

Icelus spiniger was described by Gilbert (p. 412, pl. 24, 1895) from stations in the vicinity of Unalaska Island and in Bristol Bay, Alaska. The specimen caught on the west coast of Vancouver Island represents a marked southern extension of known range for the genus and the species. Andriashev (1937) and Lindberg and Andriashev (1938) show that this species may be separated into three subspecies, *I. spiniger spiniger* Gilbert from the eastern Bering Sea and Aleutian Islands; *I. spiniger intermedius* Lindberg and Andriashev from the eastern portion of the Sea of the Okhotsk and along the eastern coast of Kamchatka in the Bering Sea; and *I. spiniger cataphractus* (Pavelenko) from the northern Japan Sea.

The genus *Icelus* is represented by seven other species and subspecies from these northern waters (Schmidt 1950). Watanabe (1960) records many specimens of *I. spiniger* from the vicinity of the island of Hokkaido in northern Japan. In the Sea of Okhotsk, Shuntov (1965) reports 54% of the 184 specimens of *I. spiniger* were caught between 150 and 200 m and 10% at depths of 350 m. These records of depth distribution and the depths at which the two specimens were caught in British Columbia coastal waters indicates that the species is normally found in moderately deep coastal water.

Some of the diagnostic characters that distinguish this sculpin are: fins: dorsal (2) IX, 20–21, anal 17, origin below that of rayed dorsal, pelvic I, 3, thoracic, pelvic 18–20, long, reaching to front of dorsal.

A complete description of meristic counts, colour, and diagnostic features are given by Gilbert (1895) and Watanabe (1960). It is distinguished from all other sculpins found in British Columbia by a single row of 28–35, large, hooked, thornlike spines from the nape to caudal and a row of 41–42 platelike ctenoid scales on the lateral line.

D. E. McAllister reports (personal communication April 26, 1966) that there is a single spine on the caudal peduncle below the lateral line near the caudal base on the specimen catalogued as NMC 65-330. A similar spine was present in a specimen

Printed in Canada (J2138)

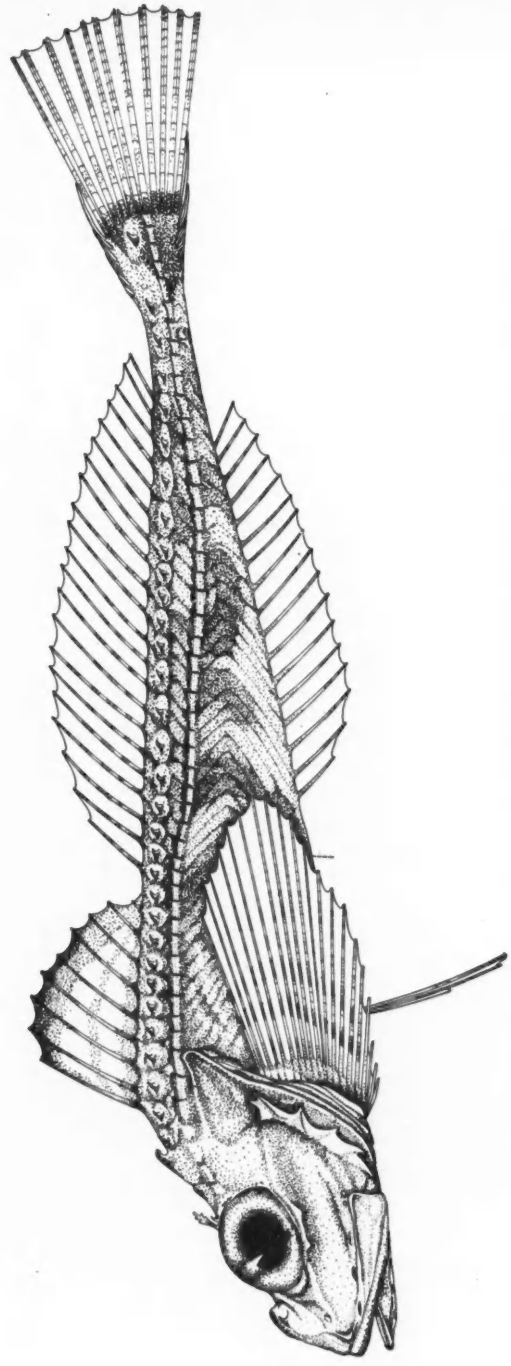

FIG. 1. Thorny sculpin (*Icelus spiniger* Gilbert), specimen BC 65-133. (Drawing by Mrs V. Nadon)

collected from Kodiak area, Alaska, and catalogued BC-145 at the Institute of Fisheries, the University of British Columbia, but the spine was absent in the specimen BC 65-133, from which the illustration was drawn. The species attains a length of 280 mm (Watanabe 1960).

ANDRIASHEV, A. P. 1937. A contribution to the knowledge of the fishes from the Bering and Chukchi Seas. U.S. Fish Wild. Serv. Spec. Sci. Rep. Fish. 145. (English transl. of Russian by L. Lanz with N. J. Wilimovsky)

BERNARD, F. R., N. BOURNE, AND D. B. QUAYLE. MS 1967. British Columbia faunistic survey. A summary of dredging activities in western Canada 1878–1966. Fish. Res. Board Can. MS Rep. 920: 61 p.

BUTLER, T. H., AND G. V. DUBOKOVIC. 1955. Shrimp and prawn prospecting on the British Columbia coast June to December 1954. Fish. Res. Board Can. Nanaimo Biol. Sta. Circ. 35: 92 p.

GILBERT, C. H. 1895 [1896]. The ichthyological collections of the steamer *Albatross* during the years 1890 and 1891. Report on the fishes collected in Bering Sea and the north Pacific Ocean during the summer of 1890. U.S. Comm. Fish Fish. Rep. Comm. Year ending June 30, 1893, Washington, D.C. p. 393–476.

LINDBERG, G. V., AND A. P. ANDRIASHEV. 1938. Obzor geograficheskikh form dal'nevostochnogo bychka *Icelus spiniger* Gilb. (A review of the geographical forms of the Far Eastern sculpin *Icelus spiniger* Gilb.) Trud. Gidrobiol. Eksped. Zool. Inst. ANSSR v 1934 g. na Yaponskom More. 1: 515–525.

SHMIDT, P. YU. 1950. Fishes of the Sea of Okhotsk. (English transl. by O. Ronen, 1965, Israel Program for Sci. Transl. No. 1263)

SHUNTOV, V. P. 1965. Vertikal' naya zonal' noct' v raspredelenii ryb v vepkhneĭ batial: Okhotskogo Morya. (Vertical zonality in fish distribution in the upper bathial of the Okhotsk Sea.) (In Russian, English summary) Zool. Zhurn. Akad. Nauk SSSR, 44: 1678–1688.

WATANABE, M. 1960. Fauna Japonica. Cottidae (Pisces). Tokyo News Service, Ltd., Tokyo, Japan, 218 p., 39 pl.

Index to Publications for 1971[1]

The Fisheries Research Board of Canada published, in 1968, Bulletin 164 containing a list of all articles, in all series, of publications and Studies that appeared up to the end of 1964, together with a subject–author index to all series. From 1965 on, a subject–author index and list of all Board publications (including Studies, Interpretive Articles, and Miscellaneous Special Publications) have been included in the last issue of each Journal volume. These follow the pattern and style used in Bulletin 164.

The present subject–author index is based on: (*a*) the 12 issues of Volume 28 of the Journal; (*b*) Bulletins 175, 176, 177, and 178 issued during 1971 (No. 176 is not subject-indexed in detail since it contains its own index); (*c*) Circular series and Technical Reports from the Board's establishments issued during 1971 in time to be included; (*d*) Miscellaneous Special Publication (which includes special bindings and pamphlets that do not belong to a particular series of FRB publications) No. 13 in French; (*e*) Studies No. 1457–1591 (reprints of articles published in other periodicals; annual two-part bindings ceased with the 1969, Part 2 issue); (*f*) general reference to the 1970 Annual Report and the 1969/1970 Review; (*g*) Interpretive Articles 58(F), 109(F), 128(F), and 178–233, which appeared in non-Board publications.

Lists of titles of the individual publications and articles immediately follow this index, arranged under the following types of publications. (The list of articles in this Volume 28 of the Journal is in the form of a table of contents of its 12 issues, suitable for binding with this volume.)

Abbreviations used in the index for types of publications:

(The designation "(F)" in the index indicates the article referred to was published in French.)

J — Journal of the Fisheries Research Board of Canada
B — Bulletin of the Fisheries Research Board of Canada
AR — Annual Report of the Fisheries Research Board of Canada
R — Review of the Fisheries Research Board of Canada (biennial)

Circulars of the Fisheries Research Board of Canada:

CHN — Halifax Laboratory, Halifax, N.S.
CJG — Biological Station, St. John's, Nfld.
CNG — Biological Station, Nanaimo, B.C.

Miscellaneous:

T — Technical Reports of the Fisheries Research Board of Canada
MSP — Miscellaneous Special Publications

Articles by FRB Staff published in non-Board publications:

S — Studies of the Fisheries Research Board of Canada
A — Interpretive Articles of the Fisheries Research Board of Canada

Other abbreviations:

The Provinces and Territories of Canada are abbreviated to:

Alta. (Alberta)	Ont. (Ontario)
B.C. (British Columbia)	P.E.I. (Prince Edward Island)
Man. (Manitoba)	Que. (Quebec)
N.B. (New Brunswick)	Sask. (Saskatchewan)
Nfld. (Newfoundland)	Yuk. (Yukon)
N.S. (Nova Scotia)	
N.W.T. (Northwest Territories)	

Certain geographical areas (particularly oceans) have their major subdivisions designated by N (north), S (south), E (east), W (west), NW (northwest), etc., also Atl. (Atlantic), Pac. (Pacific).

Certain international commissions are commonly referred to as: ICNAF (International Commission for the Northwest Atlantic Fisheries); INPFC (International North Pacific Fisheries Commission).

In the index references, "re" is frequently used to imply "in relation to," "in connection with," and similar meanings; "vs." to imply such meanings as "in contrast to," "as opposed to."

Scientific names, common names, and their spellings, for Canadian and American marine fishes taken within 200-m depth and for freshwater fishes are indexed according to the nomenclature recommended in *A List of Common and Scientific Names of Fishes from the United States and Canada* (Third Edition, 1970), Special Publication No. 6 of the American Fisheries Society. Where authors have used names or spellings not conforming to those recommended, index headings for such names are included, referring to the recommended ones under which the subject entries will be found.

[1]Subject index prepared by Neal M. Carter; November and December issues of the Journal were indexed from title pages and abstracts only.

J. Fish. Res. Bd. Canada 28: 1925–2056, 1971
Printed in Canada

A

Abnormality
J 28(8): 1198 (supernumerary copulatory organs in flatworm *Dugesia tigrina*)
(10): 1672 (ambicoloration; fin & vertebrae, in a petrale sole)
(12): 1918 (abnormal body curvature in Norwegian rainbow trout fry)
S 1536 (deformed chironomids larvae in Okanagan Valley lakes, B.C., & L. Erie, possibly caused by synthetic chemical pollutants)

Abraliopsis (*Watasenia*) *felis* (*see* Squids)

Abundance
J 28(3): 417 (seasonal, re Pac. ocean perch reproductive patterns)
(4): 573 (calculating stream-migrating kokanee fry)
(5): 755 (whelping harbour seals, Sable Is.,N. S.)
(6): 883 (Pac. cod, re environmental effects on egg development)
(7): 935 (seasonal, of fish communities components in Passamaquoddy Bay, N.B., & in warmer waters)
(9): 1269, 1275, 1293 (estimating fish, by voltage-integrating fish echo sounder)
(10): 1493 (Adams R. sockeye salmon fluctuations re year-class dominance)
(10): 1621 (northern rockfish)
B 177 (*Gonyaulax tamarensis* dinoflagellate re rate of paralytic toxin accumulation in E Canada shellfishes)
T 202 (various diatom species, NW Miramichi R. basin, N.B.)
221 (Pac. ocean perch, as taken in B.C. groundfish surveys)
260 (groundfish species, Scotian Shelf)
A 207 (N.B. & N.S. herring)

Acanthephyra (caridean shrimps)
J 28(10): 1615 (*A. curtirostris* & *A. quadrispinosa* new records, off B.C. coast)

Acanthocephala (spiny-headed worms)
T 160 (*Echinorhynchus gadi* in *Lepedion eques* morid fish)

Acanthocybium solanderi (*see* Wahoo)

Acara, Altan Hüseyin
J 28(4): 573 (enumerating kokanee fry)

Acari
J 28(6): 849 (samplings from shallow stream bed)

Acarina (parasitic)
S 1532 (of a high Colorado mountain creek)

Acclimation; Adaptation (*see* Oxygen, dissolved; Pollution; Salinity, reactions to; Temperature, reactions to)

Achnanthes minutissima (*see also* Diatoms)
J 28(2): 215 (most abundant diatom in 4 small NW Ont. lakes)

Achromobacter (*see also* Bacteria)
S 1460 (re irradiated haddock spoilage)

Acids (*see* following types, *also* names of acids)

Acids, amino (*see also* Octopine; Proteins)
J 28(4): 565 (effect on Atl. salmon olfactory epithelium electrical response)
(8): 1191 (of Dungeness crab tissues)
(12): 1837 (of rainbow trout white skeletal muscle)
S 1491 (ability of some unicellular marine algae to cleave aromatic ring)
1519 (nondestructive determination of total, in marine sediments)

Acids, fatty (*see also* Lipids; Oils and fats)
J 28(4): 601 (of sand launce oils & lipids)
(8): 1191 (composition of Dungeness crab tissues)
T 249 (re detection & estimation of marine oil adulteration of all-vegetable margarines & cooking fats)
S 1462 (structure: influence on pancreatic lipase activity)
1474 (exceptional occurrence of C_{15}, C_{17}, & C_{19}, also composition of triglycerides, cephalins & lecithins, in rainbow smelts)
1475 (confusion between C_{18} & C_{20}, in gas chromatographic analysis of water-plant seed lipids)
1481 (minor, of *Euphoria longana* seed oil)
1514 (of Amazon R. dolphin jaw & blubber wax esters, triglycerides & diacyl glyceryl ethers)
1528 (isoprenoid as breakdown product of chlorophyll in ancient lake deposit shale)
1564 (*trans*-6-hexadecenoic acid & corresponding alcohol in sea anemone *Metridium dianthus* lipids; also fatty acid composition of lipids)
1572 (saturated & isoprenoid in periwinkle, Atl. oyster & quahaug lipids)

Acids, nucleic (*see also* Enzymes; Nucleosides)
S 1560 (deoxyribonucleic acid polymerase from sockeye salmon testes)

Acinetobacter (*see also* Bacteria)
J 28(10): 1511 (associated with surfaces of hatching Pac. salmon eggs)

Acipenser fulvescens (*see* Sturgeon, lake)
medirostris (*see* Sturgeon, green)
oxyrhynchus (*see* Sturgeon, Atlantic)

Ackman, Robert George
J 28(4): 601 (investigation re commercial oil from sand lance)
T 233 (possible toxic materials in Nfld. bottom deposits)

249 (methodology for identification of marine oils in edible oil products)
254 (phosphorus levels in Nfld. water samples)
S 1474 (occurrence of odd-chain fatty acids in smelt)
1475 (confusion between C_{18} & C_{20} fatty acids in analysis of seed lipids)
1481 (fatty acids from *Euphoria longana*)
1514 (lipids of Amazon R. dolphins)
1528 (geological fate of chlorophyll)
1564 (*trans*-6-hexadecenoic acid and alcohol in sea anemone lipids)
1572 (distribution of fatty acids in lipids of 3 species of molluscs)
1591 (pristane and other hydrocarbons in fish oils)

Actiniaria (*see* Sea anemones)

Actiniscus canadensis; *A. pentasterias* (*see* Dinoflagellates)

Activity; Exercise (*see also* Stress)
J 28(4): 587 (factors influencing scope for activity & active & standard metabolism in rainbow trout)
(6): 801, 809, 815 (re fish growth efficiency from rations)
(7): 1062 (sensor apparatus for detecting lobster, in a burrow)
S 1590 : 548 (of fishes re temperature)
A 212 (energy cost of living, for fish: review)

Activity coefficient
S 1512 (isopiestic measurements on H_2O–NaCl–$MgCl_2$ system at 25 C)
1515 (as above, for H_2O–NaCl–Na_2SO_4 system)

Adams River, B.C.
J 28(10): 1493 (sockeye salmon abundance since 1938 re year-classes dominance)

Adaptation (*see* Physiology; Salinity, reactions to; Temperature, reactions to)

Addison, Richard Frederick
T 233 (possible toxic materials in Nfld. bottom deposits)
254 (phosphorus levels in Nfld. water samples)
S 1474 (occurrence of odd-chain fatty acids in smelt)

Adductor muscle (*see* Muscle; *also* Clam; Oyster; etc.)

Adenosine and derivatives (*see also* Purines)
J 28(8): 1125 (phosphate changes in Atl. fish post-mortem skeletal muscle)

Adrenal-cortical cells
J 28(4): 505 (histology of, in wild vs. hatchery land-locked Atl. salmon)

Aeromonas (*see also* Bacteria; Disease)
J 28(3): 335 (surviving ingestion by tubificids)
(10): 1629 (aberrant *A. salmonicida* strain in sablefish as first marine spontaneous furunculosis occurrence; also in cultured sockeye & chum salmon)
(10): 1511 (strains associated with surfaces of hatching Pac. salmon eggs)

Age; Age composition (*see also* Growth; Length; Size; Weight)
J 28(4): 513 (age alternation of successive sockeye salmon spawning generations)
(5): 771 (rainbow trout, Batchawana Bay, L. Superior)
(6): 821 (Skeena R. sockeye & pink salmon, re gillnet selectivity)
(7): 1009 (re S Gulf of St. Lawrence seasonal herring stocks discreteness)
(8): 1153 (winter flounder, Long Pond, Nfld.)
(9): 1335 (& growth of weathervane scallop, Washington coast)
(10): 1573 (re animal production–biomass ratio)
(10): 1493 (Adams R. sockeye salmon year cycle dominances re abundance fluctuations)
(10): 1621 (re length, northern rockfish)
(11): 1739 (young rainbow trout & chinook salmon re columnar disease susceptibility)
CNG 91 (steelhead trout, in Vancouver Is. stream-anglers' catches)
T 213 (distribution, B.C. offshore herring)
224 (ringed seal population data analysis)
259 (re length, B.C. rock sole)
S 1494 (behaviour of growth & mortality estimates based on age–length keys)
A 184 (Canadian arctic harp seal)
190 (Greenland turbot)
193 (Atl. capelin)
207 (composition, N.B. & N.S. herring)

Age determination (*see also* Bone; Marking; Otoliths; Scales, fish; Shells; Tagging; Teeth)
J 28(10): 1583 (possibilities of radioisotope X-ray fluorescence spectrometry: review)
(10): 1666 (re population biostatistical analysis)

Aggregation (*see also* Schooling)
J 28(7): 999 (spacing & density as criteria for distinguishing from schooling of fish)

Aggression (*see also* Behaviour; Mating; Spawning; Sympatry)
J 28(7): 1019 (behaviour of introduced rainbow trout)
T 235 (lobster agonistic behaviour)
S 1465 (in crayfish copulatory behaviour)
A 212 (energy cost, in fish: review)

Agonism (*see* Aggression)

Agonus acipenserinus (*see* Poacher, sturgeon)
decagonus (*see* Poacher, Atlantic)

Aiken, David Edwin
S 1557 (ovarian maturation and egg laying in crayfish)

Alaska
J 28(1): 98 (female maturity determination in shrimps)
(1): 115 (meristic differences between anadromous & freshwater-resident arctic char)

Albacore (*Thunnus alalunga*)
A 182 (ICNAF Canadian 1969 research summary)

Alberta (*see* Banff National Park; Jasper National Park; Waterton Lakes National Park)

Alcohols (*see also* Esters; Ethers; Glycol)
CHN 39 (extraction & determination of isopropano residues in fish protein concentrates)
S 1564 (*trans*-6-hexadecenol in sea anemone wax)

Alcyonaria (*see* Corals)

Alderdice, Donald Francis
J 28(5): 727 (salinity & temperature effects on petrale sole)
(6): 883 (environment re Pac. cod eggs)
(10): 1545 (salinity and temperature re Pac. herring)

Aldrich, Frederick Allen
S 1520 (food of giant squid)

Aldrin (*see* Insecticides)

Alevins (*see* name of adult fish; e.g. Salmon; Trout)

Alewife (*Alosa pseudoharengus*)
J 28(7): 935 (summer periodic component of Passamaquoddy Bay fish communities, N.B., & length frequencies)
(7): 1057 (effect of warm water of nuclear power plant discharge canal)
(8): 1215 (changes in blood lactic acid concentrations during passage through a pool & weir fishway)
(9): 1285 (methylmercury in, N.S. Banks)
T 261 (bibliography for Gulf of St. Lawrence)
S 1591 (pristane & other hydrocarbons in commercial Canadian oil)

Algae (*see also* Benthos; Diatoms; Phytoplankton; Plankton; Seaweeds; *also* classifications of)
J 28(2): 192, 215 (of several small NW Ont. lakes re primary production)
(11): 1783 (^{65}Zn vs. Zn distribution in experimental marine ecosystem)
S 1480 (vitamins composition of unicellular *Porphyridium cruentum*)
1491 (catabolic fission of phenylalanine aromatic ring by various classifications of unicellular marine)

Ali, Mohammed Youssouf
J 28(9): 1235 (medaka vertebral count re egg size)

Alkalinity (*see also* Carbonate; Hardness of natural waters; *p*H)
J 28(11): 1811 (classification index for degree of, in lakes)

Alleles (*see* Genes)

Allen, Kenneth Radway
J 28(10): 1573 (production and biomass)

Allen, William Vail
J 28(8): 1191 (tissue components in crab)

Alligatorfish (*Aspidophoroides monopterygius*)
J 28(7): 935 (regular component of Passamaquoddy Bay fish communities, N.B., & length frequencies)
T 225 (associated with Bay of Fundy scallop beds)
261 (bibliography for Gulf of St. Lawrence)

Allopatry
J 28(9): 1259 (vs. sympatry re feed & habits of Dolly Varden & cutthroat trouts in 3 B.C. lakes)

Allosmerus elongatus (*see* Smelt, whitebait)

Alopias vulpinus (*see* Shark, thresher)

Alosa aestivalis (*see* Herring, blueback)
pseudoharengus (*see* Alewife)
sapidissima (*see* Shad, American)

Aluminium derivatives
J 28(2): 277 (in sediments of 16 small NW Ont. lakes)

Ambloplites rupestris (*see* Bass, rock)

Ambystoma gracile (*see* Salamanders)

Amines (*see also* Ammonia; Dimethylamine; Trimethylamine)
J 28(1): 1 (production and differentiation in stored frozen muscle of various Atl. coast fishes)
(8): 1173 (hexosamine levels in salmon, trout, & bovine blood sera)
(8): 1191 (glucosamine content of Dungeness crab exoskeleton)
S 1497, 1498 (metabolism of putrescine by fish mycobacteria)

Amino acids (*see* Acids, amino; *also* Proteins)

Ammocoetes (*see* Lamprey)

Ammodytes americanus (*see* Sand lance, American)
dubius (*see* Sand lance, northern)
hexapterus (*see* Sand lance, Pacific)

Ammonia; Ammonium ion
J 28(5): 759 (rapid method for determination in water with univalent cation glass electrode)
(5): 788 (analysis technique for ammonium-nitrogen in artificial seawater aquaria)
T 255 (ammonium chloride toxicity tests on brook trout)
S 1519 (non-destructive determination in marine sediments)

Amphibians (*see* Frog, leopard; Newt; Salamanders)

Amphipoda
J 28(2): 257 (*Pontoporeia affinis* dominant in many small NW Ont. lakes zoobenthos)
(5): 705 (biological magnification & degradation of insecticides by fresh water)
(5): 711 (*Hyallela azteca* & *Crangonyx richmondensis occidentalis* energy flow & secondary production, Marion L., B.C.)
(5): 776 (*P. affinis* lipid & caloric content, Cayuga L., N.Y.)
(6): 928 (in feed of tidepool & fluffy sculpins)
(9): 1331 (zoogeographic problem of presence of relict *P. affinis*, L. Washington, USA)
T 165(F) (*Gammarus lacustris* re rainbow trout farming)
258 (toxicity tests of trisodium nitrilotriacetate detergent on, re pollution)
266 (Frobisher Bay, Baffin Is., N.W.T.)
S 1558, 1570 (toxicity & uptake of polychlorinated biphenyl pesticides from sea water re *G. oceanicus*)

Amylopectin
S 1585 (accumulation in *Clostridium botulinum*)

Anabiosis (*see* Revival)

Analysis, canonical (*see* Computer programming; Mathematical treatment of data)

Analysis, chemical (*see* Analysis methods (chemical); Bioassay; Composition, chemical; Limnology; Nutrients, aquatic; Oceanography; etc.)

Analysis, mathematical (*see* Computer programming; Mathematical treatment of data; Models, mathematical)

Analysis methods (chemical) (*see also* Composition, chemical)
J 28(5): 759 (rapid method for determining ammonium ion in water with univalent cation glass electrode)
(5): 769 (liquid scintillation method for ^{14}C-labelled benthic microflora)
(5): 788 (ammonium-nitrogen in artificial seawater aquaria)
(7): 1043 (nitrilotriacetic acid in inland waters)
(7): 1055 (fluoride in soil or mud by nonfusion distillation *p*F method)
(9): 1225 (methylmercury)
(10): 1583 (by radioisotope X-ray fluorescence spectrometry: review)
B 177 (paralytic shellfish toxin)
CHN 39 (isopropanol residues in fish protein concentrates)
T 217 (determining origin of petroleum oil spills causing aquatic pollution)
249 (detection & estimation of marine oil adulteration of all-vegetable margarines & cooking fats)
272 (polychlorinated biphenyls & other industrial halogenated hydrocarbons)
S 1463 (mass spectrometric identification of insecticides)
1467 (automated measurement of seawater dissolved nutrients)
1471 (colorimetric assay for pancreatic lipase, based on acetaldehyde liberation from vinyl oleate substrate)
1472 (phenosafranin as improved indicator for seawater chlorinity titrations)
1505 (fluoride in sea water by potentiometry)
1519 (nondestructive, for marine sediments protein, total amino acids, & ammonia)
1534 (flameless atomic absorption spectrophotometry procedure for mercury detection)
1569 (spectrofluorometric for fuel oil residual contamination in aquatic animals)
A 210 (sea water: book review)

Analysis, proximate (*see* Composition, chemical)

Anarhichas lupus (*see* Wolffish, Atlantic)
minor (*see* Wolffish, spotted)

Anarrhichthys ocellatus (*see* Wolf-eel)

Anas rubripes (*see* Duck, black)

Anastassiadis, Phoebus Anastassios
J 28(8): 1173 (Pac. salmon glycoprotein constituents)

Anatomy (*see also* Histology; Morphology; *also* names of anatomical structures)
J 28(10): 1672 (abnormal, of a petrale sole)
(10): 1595 (of chondrophore vs. sessile hydroid)

---

(11): 1789 (shellfish, re association of melanin pigment with presence of paralytic toxin)
B 177 (re paralytic toxin in E Canada shellfishes)

Anchovy, northern (*Engraulis mordax*)
T 257 (taken in 1970 B.C. trawl fishery)

Anderson, George Cameron
S 1466 (primary production studies in N Pac. Ocean)

Anderson, John Murray
J 28(9): 1285 (methylmercury in fish)
S 1556 (effects of temperature on brain oxygen in salmonid fishes)
A 222 (pollutants effect on physiology and behaviour)

Anderson, Robert Stewart
J 28(3): 311 (alpine and subalpine zooplankton)

Androgens (*see* Hormones)

Andrusak, Harvey
J 28(9): 1259 (cutthroat and Dolly Varden segregation)

Anesthetization
J 28(1): 113 (sampling fish muscle for residual M.S. 222 & quinaldine)
(5): 625, 635 (physiological effects of tricaine methanesulphonate on brook trout)

Anglemouth, veiled (*Cyclothone microdon*)
T 261 (bibliography for Gulf of St. Lawrence)

Angler (*see* Goosefish)

Angler, deepsea (*Ceratius holboelli*)
T 261 (bibliography for Gulf of St. Lawrence)

Angler, lesser deepsea (*Cryptopsaras couesi*)
T 261 (bibliography for Gulf of St. Lawrence)

Angling
J 28(3): 351 (relative utilization rates of Miramichi R., N.B., Atl. salmon by local angling vs. Maritime commercial fisheries)
CNG 91 (steelhead trout age & size in Vancouver Is. stream catches)
T 270 (Canadian Atl. salmon catches by provinces, 1952–70)

Anguilla rostrata (*see* Eel, American)

Animal feed (*see* Feed; Feedstuff; Fishmeal; Rations)

Anisakis (*see* Indicator species; Nematoda)

Annelids (*see also* Leeches; Oligochaeta; Polychaeta; etc.)
J 28(6): 928 (feed of fluffy & tidepool sculpins)

Anomura (*see* Crabs, hermit)

Anoplopoma fimbria (*see* Sablefish)

Anostraca (*see also* Crustacea)
J 28(3): 311 (of several W Canadian alpine & subalpine ponds)

Anoxia (*see* Oxygen, dissolved; Respiration)

Anthozoa (*see* Sea anemones)

Antia, Naval Jamshedji
S 1480 (composition of a unicellular red alga)
1491 (fission of phenylalanine by marine algae)

Antibiotics
J 28(4): 521 (sensitivity of pathogenic vibriosis bacteria to various)
A 203 (recommended as fish products preservative)

Antibodies (*see also* Disease; Viruses)
J 28(9): 1253 (production & immune responses of coho salmon & rainbow trout re *Columnaris* disease)

Antigens (*see* Antibiotics)

Antimony derivatives
J 28(5): 786 (in dressed Canadian fishes from industrial area lakes)

Antimora rostrata (Pacific) (*see* Cod, longfin)

Antipollution measures (*see also* Pollution)
J 28(12): 1912 (combating fuel oil marine spills)
T 217 (tracing origin of fuel oil spills)
250 (computer programming)
254 (elemental phosphorus release, Nfld.)
S 1476 (re implementing of Canadian ocean studies)
1500, 1504 (re pulpmill effluents)
1531 (flocculating reaction, re pollutants removal)
1539 (capacity of marine estuaries to flush away pollutants)
A 183 (re oceanography & ocean resources management)
187 (sewage removal in confined waters)
201, 230 (re environment effects on human food production)
203 (by protein recovery from fish processing wastes)
216 (re detergents)
223 (combating fuel oil, elemental phosphorus, sewage & pulpmill pollution, Canadian Atl. coast)

Apeltes quadracus (*see* Stickleback, fourspine)

Aplodinotus grunniens (*see* Drum, freshwater)

Apparatus, Equipment (*see also* names of types of fishing gear)
J 28(1): 73 (measuring insect larval respiration rates)

(1): 100 (rapid removal of embryos from fish eggs)
(2): 189 (incubation bottles holder for in situ phytoplankton production determinations)
(2): 215 (lake periphyton sampler)
(3): 305 (re detection of bacterial production of trimethylamine)
(3): 335 (oligochaete worm feces collector)
(3): 365 (corer for sampling shallow-water benthos)
(3): 379 (measuring dissolved oxygen requirements of embryonic & larval quahaug)
(4): 491 (blood perfusion for fish hypoxia studies)
(4): 559 (modified bomb calorimeter for small plankton samples)
(5): 643 (smokehouse)
(5): 655 (toxicity tests of copper sulphate towards brook trout eggs & fry)
(5): 781 (vascular catheterization procedure improvement for teleost fishes)
(6): 849 (sampling benthos & substrate materials in shallow streams)
(7): 1043 (glass ampoule for nitrilotriacetic acid assay)
(7): 1049 (mud interstitial water sampling receptacle)
(7): 1061 (practical small-scale commercial dryer for fish fillets & steaks)
(7): 1062 (sensor for detecting presence of lobster in a burrow)
(8): 1196 (digital recorder monitoring of dissolved oxygen in fish tanks)
(8): 1203 (modified biopsy needle for sampling muscle from living fish)
(8): 1205 (simple durable epifaunal collectors)
(9): 1269, 1275, 1293 (echo voltage integrator re fish density in echo sounding)
(9): 1352 (studying predation of torrent sculpin on salmon fry re moonlight effect)
(9): 1319 (testing yearling sockeye salmon reaction to polarized light)
(9): 1322 (aquatic phytomacrofauna quantitative sampler)
(10): 1583 (radioisotope X-ray fluorescence spectrometry)
(10): 1511 (incubating Pac. salmon eggs for examining bacterial flora of their surfaces)
(11): 1815 (dispenser for simultaneous delivery of Winkler reagents for dissolved oxygen)
(11): 1805 (photographic, for estimating distances between fish schooling in aquaria)
B 178 (re raft-culturing of Pac. oyster in B.C.)
T 215 (photo-electric fish counter)
232 (sampling razor clam beds)
236 (culturing mud dab eggs & larvae)
249 (aspirating thin-layer chromatography material)
252 (modified Icelandic high-speed plankton sampler)
255 (testing yellow phosphorus production wastes toxicity toward fish)
264 (fluid mechanics of netting & low-solidity screens)
S 1461 (thermistor readout monitor for cold storage temperatures)
1473 (portable refrigerated unit for holding iced freshwater fish)
1502 (automatic wet-feed dispenser for fish culture)
1518 (prawn traps)
1522 (pressure-jump bomb with optical detection)
1534 (syringe procedure re flameless atomic absorption spectrophotometric detection of mercury)
1554 (recording pressure changes & oxygen consumption in fish respiratory cavities)
1565 (removal of nematodes cephalic sections)
A 128(F) (experimental prawn trap, B.C.)
178 (details of assay procedure for fish by flameless atomic absorption spectrophotometry)
225 (resume of S 1473 above)

Appetite (*see* Feed)

Applegate, Vernon Calvert
S 1484 (molecular structure & biological activity among mononitrophenols containing halogens)

Apristurus brunneus (*see* Shark, brown cat)

Aquaria (*see also* Tanks)
J 28(5): 788 (analysis method for ammonium-nitrogen in artificial sea water)
(11): 1805 (photographic estimation of distances between schooling fish in)

Aquiculture (*see* Culture; Feed; Hatcheries; Ponds; Rations)

Arai, Hisao Philip
J 28(5): 767 (new species of helminth parasites from California embiotocid fishes)
(10): 1645 (N and Central American species of *Rhabdochona*)

Arai, Mary Needler
J 28(10): 1677 (*Pachycerianthus* from B.C. and Washington)
(10): 1365 (publications by Edith and/or Cyril Berkeley)

Araphidineae
J 28(2): 265 (dominant diatoms in many small NW Ont. lakes)

Abbreviations: J — *Journal.* B — *Bulletin.* AR — *Annual Report.* R — *Review. Circular Series:* CHN — Halifax; CNG — Nanaimo; CJG — St. John's. T — *Technical Reports.* MSP — *Miscellaneous Special Publications.* S — *Studies.* A — *Interpretive Articles.*

Architeuthis dux (*see* Squid, giant)

Archoplites interruptus (*see* Perch, Sacramento)

Arctic (*see also* Oceanography, arctic; *also* names of islands, organisms, etc.)
B 176 (synopsis of Canadian marine zooplankton; *see* its index)
T 231 (potential arctic char production in Keyhole L., Victoria Is., Canada)
MSP 13(F) (French translation of MSP 13 — FRB studies in Canada's Arctic)
S 1488 (new genus & species of dinoflagellates as marine relicts in Canadian arctic lakes)
A 220 (re C.S.S. *Hudson* circumnavigation of N & S America)
231 (FRB studies in Canada's Arctic)

Arctica islandica (*see* Quahaug, ocean)

Argentina silus (*see* Argentine, Atlantic)

Argentine, Atlantic (*Argentina silus*)
J 28(9): 1285 (methylmercury in, N.S. Banks)
T 260 (standing crop, availability, weights, lengths) etc., from Scotian Shelf surveys, 1958–68,
S 1483 (morphometric variation in trematode parasite)
A 182 (ICNAF Canadian 1969 research summary)

Armour, Carl Lee
J 28(5): 788 (analysis of ammonium-nitrogen in artificial seawater aquaria)

Armstrong, Francis Adolf John
J 28(2): 171 (chemical characterization of FRB Experimental Lakes waters, NW Ont.)
(2): 215 (periphyton of FRB Experimental Lakes, NW Ont.)
(11): 1763 (eutrophication of 1 of FRB Experimental Lakes, NW Ont.)
A 178 (determination of residual mercury in fish tissue)

Armstrong, Milton Connor
T 215 (photo-electric fish counter)

Arsenic derivatives
J 28(5): 786 (in dressed Canadian fishes from industrial area lakes)

Artediellus uncinatus (*see* Sculpin, arctic hookear)

Arthropoda (*see* classifications of; *also* names of species)

Arthur, John Wentworth
J 28(12): 1841 (chloramine toxicity to amphipod and minnow)

Ash (*see also* Composition, chemical)
J 28(1): 73 (content of some thermal spring aquatic insects)

Aspidophoroides monopterygius (*see* Alligatorfish)

Assay methods (*see* Analysis methods (chemical); Bioassay)

Assimilation ratios (*see also* Metabolism)
J 28(5): 790 (effect on phytoplankton, by enrichment of N. Pac. sea waters)

Associations (biological) (*see also* Communities)
J 28(11): 1683 (benthic macroinvertebrates in L. Ontario bays)
T 225 (invertebrates on Bay of Fundy scallop beds)
S 1580 (classification & ordination of many shallow-water benthic samples, P.E.I.)

Asterias forbesi (*see* Starfish, common)
vulgaris (*see* Starfish, common)

Asteroidea (*see* Starfishes)

Atheresthes stomias (*see* Flounder, arrowtooth)

Atlantic Ocean (*see also* Fisheries; Oceanography; names of organisms, etc.)
T 199 (invertebrate (6) & fish (122) species taken during otter-trawl survey from off Delaware Bay to off Fort Pierce, Florida, 1969)

Aulichthys japonicus (*see* Tube-snouts)

Aulorhynchidae (*see* Tube-snouts)

Aulorhynchus flavidus (*see* Tube-snout)

Aulstad, Dag
J 28(12): 1918 (abnormalities in trout)

Availability (*see also* Catches; Fisheries)
T 260 (groundfish species, Scotian Shelf, from 1958–68 surveys)

Avoidance reaction
J 28(8): 1167 (American shad re nets)
A 222 (zinc & copper vs. DDT, at sub-lethal levels, by salmonids)

B

Babine Lake and River, B.C.
J 28(3): 369 (identification of sockeye salmon populations by X-ray spectrometry & multivariant analysis)

Bacillariophyceae (*see* Diatoms; Phytoplankton)

Bacteria (*see* also Bacteriophyta)
J 28(1): 104 (morphology of *Pseudomonas*-like proteolytic pseudomonad causing rainbow trout skin lesions)

(3): 305 (*Pseudomonas putrefaciens* & other bacteria producing trimethylamine from trimethylamine oxide in chilled haddock fillets)
(3): 335 (*Flavobacterium, Pseudomonas, Aeromonas & Micrococcus* in Toronto Harbour sediment surviving ingestion by 3 tubificid oligochaete species)
(4): 517 (morphology & taxonomy of *Vibrio anguillarum* re first records of vibriosis in Pac. salmon cultured in Canada; correction on J 28(8): 1219)
(4): 533 (Columbia R. fish ladders influence on *Chondrococcus columnaris* disease of fishes)
(5): 643 (gamma irradiation effects on *Salmonella* spp.)
(5): 783 (beneficial effect of washing off slime as bacterial medium on freshwater fish keeping quality)
(8): 1185 (counts in commercial fish diets)
(10): 1629 (aberrant *Aeromonas* strain)
(10): 1511 (characterization, identification & ecology of *Pseudomonas* & other bacterial flora associated with surface of hatching Pac. salmon eggs, re egg mortality)
CHN 40 (red crab resistance to *Gaffkya homari* lobster disease)
41, 42 (nature & control of gaffkemia in lobsters)
T 218 (antibacterial effects of sea water, particularly re *E. coli*)
S 1460 (re irradiated haddock spoilage by *Pseudomonas & Achromobacter*)
1485 (role of marine, as zooplankton feed)
1497, 1498 (metabolism of putrescine by mycobacteria isolated from fish)
1500 (*Desufovibrio desulfuricans* production of hydrogen sulphide in marine sediments from pulpmills)
1503 (role in formation of small suspended seawater particles)
1559 (ingestion by *Uronema* marine ciliate)
A 180 (*Gaffkya homari* & pathological effects on lobster)
A 203 (*Clostridium botulinum & C. perfringens* re fish spoilage)

Bacteriophyta
J 28(2): 192 (of several small NW Ont. lakes)

Baffin Island, N.W.T. (*see* Cumberland Sound; Frobisher Bay)

Balaena mysticetus (*see* Whale, bowhead)

Balaenoptera acutorostrata (*see* Whale, minke)
physalus (*see* Whale, fin)

Balanus (*see* Barnacles)

Balloonfish (*Diodon halocanthus*)
J 28(11): 1809 (new record of lymphocystis viral infection in, E Pac.)

Banerjee, Tapan
J 28(7): 1051 (California seaperch maturity and fecundity)

Banff National Park, Alta.
J 28(3): 311 (crustacean plankton of 49 alpine & subalpine lakes and ponds)

Banse, Karl
J 28(10): 1469 (new species and revised descriptions of Polychaeta)

Baptist, John Paul
J 28(11): 1783 (distribution of radioactive zinc in marine ecosystem)

Barica, Jan
J 28(5): 759 (rapid determination of ammonium in water)

Barlow, John
J 28(1): 15 (isozyme polymorphisms in American lobster)

Barnacles
T 225 (associated with Bay of Fundy scallop beds)
266 (Frobisher Bay, Baffin Is., N.W.T.)

Barner, Leonard Walter
T 213 (B.C. offshore herring survey, 1969–70)

Barraclough, William Edward
J 28(9): 1345 (anomalous occurrence of carp in marine environment)
(10): 1681 (whitebait smelt recorded in B.C. waters)
(12): 1922 (new sculpin in B.C. coastal waters)

Barracudina, white (*Paralepis rissoi krøyeri*)
T 261 (bibliography for Gulf of St. Lawrence)

Bass, largemouth (*Micropterus salmoides*)
J 28(1): 113 (sampling flesh for anesthetic residues)
(7): 957 (vulnerability to northern pike predation)

Bass, rock (*Ambloplites rupestris*)
J 28(1): 45 (populations upstream & downstream of a dammed Ont. lake)
A 201 (mercury contamination, Great Lakes)

Bass, smallmouth (*Micropterus dolomieui*)
J 28(7): 957 (vulnerability to northern pike predation)
(9): 1285 (methylmercury in N.B.)

A 201 (mercury contamination, Great Lakes)

Bass, striped (*Morone* (*Roccus*) *saxatilis*)
J 28(12): 1823 (handling & salinity effects on oxygen requirements)
T 261 (bibliography for Gulf of St. Lawrence)

Bass, white (*Morone* (*Roccus*) *chrysops*)
T 261 (bibliography for Gulf of St. Lawrence)
A 201 (mercury contamination, Great Lakes)

Batchawana Bay, Lake Superior (*see* Trout, rainbow)

Bathymetry
J 28(2): 139 (of many small NW Ont. lakes)

Bathythermograph (*see also* Oceanography; Temperature)
J 28(1): 102 (plotting transect data on computer printer)

Beak
J 28(4): 620 (shape as identification of *Abraliopsis felix* squid re N Pac. coast range extension)

Beamish, Frederick William Henry
A 197 (metabolism and biological production in fish)

Beamish, Richard James
J 28(11): 1745 (biochemical and cytological study of suckers)

"Beard" (of mussels) (*see* Byssus)

Beck, Brian
S 1573 (harbour seal in Thlewiaza R., N.W.T.)

Bedford Basin, N.S.
T 247 (phytoplankton production & nutrients, 1969–70)
S 1482 (eutrophication study)
1586 (phytoplankton production, export & grazing, during a 25-hour period)

Behaviour (*see also* Activity; Diel habits; Environment; Feed; Light, reactions to; Mating; Migration; Odour; Reproduction; Salinity, reactions to; Schooling; Spawning; Swimming; Temperature, reactions to; etc.)
J 28(7): 1019 (role of social, in dispersal of introduced rainbow trout)
(8): 1167 (net avoidance, of American shad)
(9): 1309 (white whale, Cumberland Sound, Baffin Is., N.W.T.)
(10): 1595 ("concert" of *Vellela*, re chondrophore evolution)
(12): 1847 (effect of experience in predation by rainbow trout)
T 235 (agonistic, of lobsters)
S 1465, 1468, 1486 (copulatory; egg-laying; maternal–offspring; of the crayfish *Pacifastacus trowbridgii*)
1535 (sexual, of hypophysectomized & gonadectomized female guppies after treatment with chinook salmon gonadotropin)
1551 (feeding & locomotion of postlarval *Macoma balthica* clam)
1555 (during attempted mating between male green shore crabs)
A 222 (assessment of pollutants effects on fish)

Behnke, Robert John
J 28(7): 987 (Kern R. trouts)

Bell, Gordon Russel
J 28(10): 1511 (identification of bacterial flora in salmon streams)
T 245 (B.C. wild fish mortalities)

Bell, William Harold
T 215 (photo-electric fish counter)

Bellingham Bay, Washington, USA
J 28(9): 1241 (incidence of skin tumours on flounder species)

Belonje, Bartholomeus
J 28(6): 843 (zinc retention in young rats fed increasing levels of high-zinc oysters)

Beluga (*see* Whale, white)

Belwood Lake (*see* Grand River, Ont.)

Benoit, Duane Awve
J 28(5): 655 (trout re toxicity of copper)

Benthos
J 28(1): 35 (differences upstream & downstream of a dammed Ont. lake)
(2): 257 (zoobenthos of 15 small NW Ont. lakes)
(3): 365 (sampling by simple corer vs. Ekman grab)
(5): 769 (assay method for ^{14}C-labelled benthic microflora)
(6): 849 (sampling minute, in shallow streams)
(11): 1683 (macroinvertebrates associations & species diversity in L. Ontario bays)
(11): 1699 (macroinvertebrates production in L. Ontario bays)
(11): 1715 (macroinvertebrate community metabolism in L. Ontario bays)
T 225 (distribution, Bay of Fundy)
S 1543 (Oligochaeta, Sphaeriidae & Chironomidae of Georgian Bay, L. Ontario, & L. Erie)
1580 (classification & ordination of many shallow marine species, P.E.I.)

Benthosema glaciale (*see* Lanternfish glacier)

Berkeley, Edith and Cyril (for new Polychaeta genus and several new Polychaeta species recently named after them, *see* Genera; Species new)

J 28(10): 1360 (an appreciation of: entire issue is dedicated to them)
(10): 1365 (list of their publications)

Bernard, Frank Rheinhold
T 218 (evaluation of shellfish growing areas)
268 (survey report on B.C. Brachiopoda)
S 1469 (occurrence of spirochaete *Cristispira* in marine bivalves)
1470 (checklist of marine molluscs of B.C.)

Besch, Karl Wulf
T 202(F) (diatoms as indicators of mine pollution)
S 1553 (effects of mining pollution on Miramichi R. plants)

Bibliographies (*see also* Review papers)
J 28(10): 1365 (of publications by Edith & Cyril Berkeley)
(10): 1407 (abyssmal polychaetous annelids)
T 151 (coregonid fishes)
176 (lake trout, 1929–1969)
209 (storage & retrieval of indexed & annotated bibliographical references)
232 (arctic char)
241 (pandalid shrimps, with emphasis on economically important *Pandalus* species)
T 246 (N America Pac. coast trawl fishery & groundfish)
261 (for 145 Gulf of St. Lawrence fishes)
272 (halogenated hydrocarbons industrial uses, re detection & effects on environment)
S 1590 (environmental temperature effects on fishes: review)

Bicarbonate (*see* Carbonate; Hardness of natural waters)

Bideford River, P.E.I.
S 1580 (classification & ordination of shallow-water estuarial benthos)

Bigeye, (*see* Pollock, Pacific)

Biggs, Robert Bruce
J 28(6): 911 (C:N relations in Chesapeake Bay)

Bilinski, Edward
J 28(7): 1015 (trout lysosomal lipase)

Bilton, Herbert Thomas
J 28(4): 513 (alternation of age of return in sockeye successive generations)
(6): 861 (effects of feeding level on scales of young salmon)
(11): 1757 (effect of starvation on scales of salmon)
(11): 1757 (response of young salmon to starvation periods)
T 223 (data and computations used in racial analyses of sockeye salmon)
234 (data and computations in racial analyses of N American pink salmon)

Bioassay
B 177 (for paralytic shellfish toxicity, using mice)

Bioenergetics (*see also* Activity; Metabolism; Stress)
J 28(1): 73 (& natural history of a thermal spring dipteran herbivore)
(5): 711 (energy flow re secondary production of 2 amphipod species, Marion L., B.C.)
(6): 801, 809, 815 (fish growth efficiency re rations & activity)
(8): 1113 (re brook trout rations calorie-to-protein ratio)
S 1538 (energy flow & species diversity in marine plankton bloom)
1579 (of annual phytoplankton production, St. Margaret's Bay, N.S.)
1590 : 534 (of fishes re environmental temperature & acclimation: review)
A 197 (biological production in freshwater fishes re their metabolism: review)
211 (re feed availability to different trophic levels in marine feed chain)
212 (energy cost of living, for fish: review)
233 (sun as primary energy source of ecosystems)

Biography
J 28(10): 1360 (Edith & Cyril Berkeley)

Bioluminescence
J 28(10): 1487 (in pelagic polychaetes)

Biomass (*see also* Benthos; Matter, particulate; Phytoplankton; Plankton; Productivity; Zooplankton)
J 28(2): 189, 245, 257 (of several small NW Ont. lakes)
(2): 295 (re differences & similarities among small NW Ont. lakes)
(9): 1269, 1275, 1293 (estimating fish abundance by voltage-integrating echo sounding)
(10): 1573 (mathematical models of animal production–biomass ratio)
T 252 (ecology of macrozooplankton, Scotian Shelf)
260 (groundfish, Scotian Shelf)
S 1482 (zooplankton, Bedford Basin & St. Margaret's Bay, N.S.)
1586 (zooplankton, re phytoplanktonic chlorophyll budget)
A 188 (Saanich Inlet, B.C., primary & secondary)
211 (re feed availability to different trophic levels in marine feed chain)

Biosynthesis (*see also* Enzymes; Photosynthesis; Productivity, primary)
J 28(5): 769 (assay method for ^{14}C-labelled benthic microflora)

Biota (*see* Fauna; Flora; *also* forms and types of)

Birds (*see also* names of species)
J 28(12): 1877 (DDT accumulation & persistence in)
B 177 (susceptibility to paralytic shellfish poisoning, E Canada)
T 210 (observed during trawl survey off SW coast of Vancouver Is.)
272 (halogenated hydrocarbons detected in eggs of aquatic)

Bivalves (*see* Pelecypoda)

Blackbourn, David John
J 28(3): 391 (red-water ciliate *Mesodinium rubrum*)

Blackbourn, Janice
J 28(3): 391 (red-water ciliate *Mesodinium rubrum*)

Blackcod (*see* Sablefish)

Blackflies
J 28(1): 105 (*Simulium articum* control in Saskatchewan R. leaves DDT residues in fish flesh)
S 1533 (of a high Colorado mountain creek)

Blease, John Alden
J 28(12): 1877 (DDT in lotic ecosystem)

Blenny, snake (*see* Snakeblenny)

Blenny, Yarrell's (*see* Warbonnet, Atlantic)

Bligh, Emerson Graham
J 28(5): 786 (heavy metal contamination of freshwater fish)
A 200 (mercury contamination in fish)
201 (contamination of Great Lakes fish)

Blood; Blood constituents (*see also* Enzymes; Heart; Hemoglobin; Proteins; Respiration; Serum)
J 28(1): 47 (hemosiderin re erythropoiesis in blue gourami spleen, kidney & liver tissues)
(1): 112 (leukemic condition in a cutthroat trout with sarcomas)
(4): 491 (cardiac responses to hypoxia in sea raven)
(4): 606 (chemical values for juvenile coho salmon)
(4): 610 (dieldrin insecticide residues in green sunfish)
(4): 613 (blood plasma esterase properties of channel catfish, also esterase activity of some other fish blood plasmas)
(5): 625, 635 (physiological & chemical changes in brook trout by handling, anesthetization, & surgery)
(5): 781 (improved vascular catheterization procedure for teleost fish aorta)
(6): 843 (re regulation of zinc retention by rat, when fed P.E.I. oysters)
(6): 903 (habitat of two fluke species in N Pac. rockfishes, re habitat of those fishes)
(7): 947 (pathway effects on pressure drop in teleost gills)
(7): 1053 (genic polymorphism of tetrazolium oxidase in bluefin tuna)
(8): 1173 (glycoproteins constituents levels in Pac. salmons, trouts, & bovine sera)
(8): 1191 (hemolymph amino acids of Dungeness crab)
(8): 1208 ("hemagglutinogens" re mummichog & striped killifish erythrocytes)
(8): 1215 (changes in lactic acid concentrations of stressed alewives)
(10): 1609 (effects on circulation, from artificial manipulation of rainbow trout gills)
(12): 1831 (stresses caused by formalin disinfection of young salmonids)
(12): 1853 (proteins in coho salmon)
T 255 (effects of yellow phosphorus production wastes on several fish species)
S 1489 (proteins binding affinities for sex hormones & corticosteroids in 3 Atl. fishes)
1562 (major androgens in sexually maturing Atl. salmon plasma)
1576 (corticosteroids & testosterone in Atl. sturgeon plasma)

Bloom (*see* Phytoplankton)

Blubber (*see also* Whale)
S 1514 (fat composition re Amazon R. dolphin echolocation ability)

Bluefish (*Pomatomus saltatrix*)
T 272 (halogenated hydrocarbon residues detected in)

Bluegill (*Lepomis macrochirus*) (bluegill sunfish)
J 28(1): 113 (sampling flesh for anesthetic residues)
(3): 449 (nitrogen excretion & protein consumption)
(7): 957 (vulnerability to northern pike predation)

Bocaccio (*Sebastes* (*Sebastodes*) *paucispinis*)
J 28(6): 903 (habitat of a blood fluke species in)
T 221, 269 (taken during B.C. groundfish surveys)
246 (bibliography)
257 (taken in B.C. trawl fishery, 1970)

Boddington, Martin John
J 28(1): 7 (chemical composition of *Dugesia tigrina*)
(8): 1198 (abnormal sexual organs in fish)

Boese, Helen
J 28(9): 1325 (postmortem changes in fish muscle)

Bomolochus cuneatus (parasitic copepod)
J 28(10): 1563 (threespine stickleback & pile perch as new hosts)

Bone (*see also* Osteology)
J 28(6): 843 (zinc retention in rat, when fed P.E.I. oysters)
A 229 (aging whales & other mammals by layered structure of: book review)

Bonito, Atlantic (*Sarda sarda*)
T 261 (bibliography for Gulf of St. Lawrence)

Book reviews (*see* Reviews of books)

Boreogadus saida (*see* Cod, arctic)

Boron derivatives
S 1549 (tropylium ion origin in arylboronic acid esters mass spectra)

Bose, Robert John
S 1531 (casein and polyethylenimine)
1549 (occurrence and origin of tropylium ion in mass spectra of arylboronic acid esters)

Bosmina (*see* Cladocera)

Bothidae (lefteye flounders) (*see also* names of species)
T 246 (bibliography of Pac. N America coast)

Bottom organisms (*see* Benthos; *also* names of species)

Bottom sediments (*see* Sediments)

Botulism; *Clostridium botulinum*
J 28(8): 1071 (sodium chloride effects on toxin production in Pac. cod flesh homogenates)
(11): 1733 (acid phosphatase activity in vegetative cells & spores)
S 1585 (amylopectin accumulation in bacterium)
A 201 (re wildlife consumption of Great Lake fishes)
203 (sources of bacterium if found in fishery products)

Boulder Creek, Colorado (*see* North Boulder Creek, Colorado)

Boulva, Jean
J 28(5): 755 (seal whelping observations, Sable Is.)

Bourget, Edwin
J 28(8): 1205 (epifaunal collectors)

Bourne, Neil
T 232 (breeding and growth of razor clams in B.C.)

Boyce, Norbert Patrick Joseph
S 1565 (dissecting instrument with increased accuracy and cutting efficiency)

Boyd, John William
J 28(8): 1071 (salt tolerance of type E *Clostridium botulinum*)

Brachiopoda
J 28(10): 1675 (*Terebratalia transversa* sterols)
T 225 (*T. septentrionalis* associated with Bay of Fundy scallop beds)
268 (surveys, B.C. coast since 1960)

Brachyura (*see* Crab; Crabs)

Brain
J 28(4): 610 (dieldrin insecticide residues in green sunfish)
(12): 1837 (lysolecithin solubilizing effect on extractability of tissues, in rainbow trout)
S 1556 (temperature effects on Atl. salmon & brook trout oxygen consumption of)

Breeding (*see* Culture; Hatcheries; Reproduction; Spawning)

Brett, John Roland
J 28(3): 409 (sockeye satiation time, appetite, & maximum food intake)
(10): 1635 (diet–growth responses of salmon)
S 1590 (temperature in fishes)
A 212 (metabolism in fish)

Brevoortia tyrannus (*see* Menhaden, Atlantic)

Brill, Pacific (*see* Sole, petrale)

Brinkhurst, Ralph Owen
J 28(3): 335 (tubificid oligochaetes & bacteria)
(11): 1683 (L. Ontario benthos species diversity)
(11): 1699 (L. Ontario benthos production)
(11): 1715 (L. Ontario benthos community metabolism)
S 1543 (components of bottom fauna; Great Lakes)

British Columbia (*see also* Oceanography, Pacific coast; Yoho National Park; *also* names of localities and bodies of water)
B 178 (Pac. oyster raft culture in)
T 210, 221, 269 (catches during groundfish surveys)
213 (offshore herring surveys)
216, 257 (commercial trawl fishery catch & effort statistics, 1969)
246 (bibliography of trawl fishery & fishes)
A 200 (mercury contamination of fishes & crabs)

Brittle stars (*see* Starfishes)

Brockerhoff, Hans
J 28(11): 1793 (effects of oil on cardiac functions of rats)

T 229 (effects of herring oil on organs of rats)
S 1462 (substrate specificity of pancreatic lipase)
1471 (lipase assay based on acetaldehyde liberation from vinyl oleate)

Brodie, Paul Frederick
J 28(9): 1309 (white whale life history)

Brosme brosme (*see* Cusk)

Broughton, Eric
J 28(3): 448 (subcutaneous fibroma in lake trout in Quebec)

Brown, Clinton Eugene
J 28(7): 947 (blood pathway and pressure drop in fish gills)

Brown, Penelope Louise
J 28(10): 1433 (relation between tube-building and feeding in Polychaeta)

Brungs, William Aloysius
J 28(8): 1119 (low oxygen effects on minnows)

Brunskill, Gregg John
J 28(2): 139 (geography and bathymetry of selected basins of FRB Experimental Lakes, NW Ont.)
(2): 277 (surface sediment chemistry of FRB Experimental Lakes, NW Ont.)
(11): 1763 (eutrophication of 1 of FRB Experimental Lakes, NW Ont.)

Bryozoa
T 225 (associated with Bay of Fundy scallop beds)

Bubbles
S 1500 (mathematical physics of formation in bottom sediments)

Buccinum undatum (*see* Whelk, rough)

Budlong, John Perry
S 1516 (bridge and amplifier monitor)
1517 (frequency divider immunity)

Buffalo, bigmouth (*Ictiobus cyprinellus*)
J 28(7): 957 (vulnerability to northern pike predation)

Bullhead, black (*Ictalurus melas*)
J 28(4): 613 (blood plasma esterase activity)
(7): 957 (vulnerability to northern pike predation)
(11): 1811 (alkali tolerance in Nebraska eutrophic lakes & ponds)

Bullhead, brown (*Ictalurus nebulosus*)
J 28(9): 1285 (methylmercury in N.B.)

Bullhead, yellow (*Ictalurus natalis*)
J 28(4): 613 (blood plasma esterase activity)

Buoys (*see* Currents)

Burbot (*Lota lota*) (maria)
J 28(1): 105 (DDT residues in muscle of, Saskatchewan R.)
(7): 1061 (practical drying equipment for fillets & steaks)
S 1591 (pristane & other hydrocarbons in commercial Canadian oil)
A 200 (mercury contamination in various Canadian waters)

Bursa, Adam Stanislaw
T 267 (Frobisher Bay 1967 phytoplankton tables)
S 1488 (marine relicts in Canadian arctic lakes)
1577 (new organisms discovered in Como Creek, Colorado)
1578 (rare plankton species discovered on Ellesmere Is., N.W.T.)
1589 (morphogenesis and taxonomy of fossil and contemporary dinophyta secreting discoasters)

Butler, David Gordon
S 1526 (feedback mechanism in eels)

Butler, John
J 28(9): 1349 (notacanthid collected off Oregon coast)

Butler, Terrance Henry
J 28(10): 1615 (records of B.C. shrimp)
T 241 (bibliography of economically important shrimps)
S 1518 (biological data on prawn)

Butterfish (*Peprilus* (*Poronotus*) *triacanthus*)
J 28(7): 935 (occasional component of Passamaquoddy Bay fish communities, N.B.)
T 261 (bibliography for Gulf of St. Lawrence)

Buttkus, Hans
S 1509 (accelerated denaturation of myosin)
1561 (sulfhydryl content of rabbit and trout myosins in relation to protein stability)

By-products, fishery (*see also* Crabmeal; Fishmeal; Fish protein concentrate; Oils and fats; Shrimpmeal; etc.; *also* types of processing)
A 215 (technology of: book review)

Byssus ("beard")
B 177 (re paralytic shellfish toxin in E Canada mussels)

C

Cabezon (*Scorpaenichthys marmoratus*)
J 28(10): 1563 (host of a new copepod species)
T 246 (bibliography)
257 (taken in 1970 B.C. trawl fishery)

Caddisflies (Trichoptera) (*see also* Insects, aquatic)
J 28(1): 35 (differences upstream & downstream of a dammed Ont. lake)

(6): 849 (samplings from shallow stream bed)
T 258 (toxicity tests of trisodium nitrilotriacetate detergent on, re pollution)
S 1532, 1533 (of a high Colorado mountain creek, including a new species, *Hesperophylax oreades*)

Caddy, John Frederick
T 225 (fauna in Bay of Fundy scallop dredge hauls)
256 (Georges Bank scallop meat sizes)
S 1551 (study of developments in postlarval *Macoma balthica*)

Cadmium derivatives
J 28(5): 786 (in dressed Canadian fishes from industrial area lakes)
(6): 843 (level in P.E.I. oysters)
(9): 1225 (toxicity tests on mummichogs & various marine organisms)
S 1529 (distribution in L. Ontario)

Caeca, pyloric
J 28(1): 115 (count, re anadromous vs. freshwater-resident arctic char)
(7): 987 (counts re systematics & evolution of western N America *Salmo* species & subspecies)
(7): 1064 (vs. feces re presence of pancreatic necrosis virus in brook trout)

Caesium derivatives
A 232 (^{137}Cs as radioactive marine pollutant)

Cairns, John, Jr.
J 28(8): 1107 (computer simulation of pollution minnow deaths)

Calanoida; *Calanus* (*see also* Copepoda)
J 28(2): 231, 245 (communities, vertical distribution & abundance in some small NW Ont. lakes)
(9): 1327 (*C. finmarchicus* tolerance to fuel oil spills; fecal sedimentation of oil)
T 248 (*C. pacificus* culture & grazing re marine productivity)
S 1513 (*Calanus* grazing re marine productivity)
A 211 (*C. plumchrus* & *Pseudocalanus minutus* re juvenile Pac. salmon feed)

Calaprice, John Robert
J 28(3): 369 (X-ray fluorescence analysis of sockeye)
(10): 1583 (X-ray spectrometry)
T 200 (discrimination of salmonids by X-ray analysis)
212 (IBM programs for X-ray data)
222 (genetics & mariculture)

Calastacus (crabs)
J 28(10): 1527 (*C. quinqueseratius* range extension off B.C.)

Calcium derivatives (*see also* Carbonate; Hardness of natural waters)
J 28(2): 171, 203 (in waters of many small NW Ont. lakes)
(2): 277 (in sediments of 16 small NW Ont. lakes)
(5): 625, 635 (level changes in brook trout after handling, anesthetization, & surgery)

Caligidae (*see also* Calanoida; Copepoda)
J 28(3): 323 (taxonomy & nomenclature re *Lepeophtheirus* vs. *Dentigryps*)
(8): 1143 (locomotory mechanisms)

Caligus (parasitic copepods) (*see also* Caligidae)
J 28(8): 1143 (*C. clemensi* locomotory mechanisms)
S 1499 (redescription of *C. rapax*, a misuse of nomenclature since 1850)

Callianassa (crabs)
J 28(10): 1527 (*C. gigas* range extension off B.C.)

Callorhinus ursinus (*see* Seal, northern fur)

Caloric content
J 28(1): 73 (thermal spring biota)
(4): 559 (seasonal, of freshwater zooplankton in 3 small E Ont. lakes, by modified bomb calorimeter)
(5): 711 (2 amphipod species, re bioenergetics, Marion L., B.C.)
(5): 776 (*Pontoporeia affinis* amphipod, Cayuga L., N.Y.)
(7): 971 (*Sagitta elegans* chaetognath, St. Margaret's Bay, N.S.)
(8): 1113 (calorie-to-protein ratio re brook trout rations)

Calorimeter
J 28(4): 559 (modified Phillipson bomb, for small zooplankton samples)

Camp, Bennie Joe
J 28(5): 788 (analysis of ammonium-nitrogen in artificial seawater aquaria)

Campbell, James Scott
J 28(3): 452 (world distribution of brook trout, further observations)

Campbell, Robert Seymour
J 28(5): 705 (pesticide accumulation in invertebrates)

Cancer borealis (*see* Crab, Jonah)
irroratus (*see* Crab, rock)
magister (*see* Crab, Dungeness)

Cannibalism
J 28(7): 957 (northern pike)
S 1486 (of young, by adult *Pacifastacus trowbridgii* crayfish)

Canning; Canned products
B 177 (effects on paralytic shellfish toxin)
T 220 (effects of storing sockeye salmon in ice vs. refrigerated sea water, on quality of canned product)
242 (as for T 220 above, using salt-fortified sea water; also effect of mishandling)
A 203 (colour enhancement for salmon)

Canonical analysis (*see* Mathematical treatment of data)

Canthaxanthin (*see* Pigments)

Cantin, Ruth
T 202(F) (diatoms as indicators of mine pollution)

Capelin (Atlantic) (*Mallotus villosus*)
J 28(7): 935 (winter periodic component of Passamaquoddy Bay fish communities, N.B. & length frequencies)
(7): 1029 (fecundity of right vs. left ovary)
T 261 (bibliography for Gulf of St. Lawrence)
A 181 (ICNAF Canadian 1969 research summary)
185 (as latent resource for Nfld.)
193 (biology, distribution, fisheries)
194 (Nfld. fishery)
200 (mercury contamination, Hudson Bay)

Capelin (Pacific) (*Mallotus villosus*)
A 193 (biology, distribution, fishery)

Caprella
J 28(6): 928 (in feed of fluffy & tidepool sculpins)

Caranx crysos (*see* Runner, blue)

Carapace
J 28(8): 1191 (fatty & amino acids of Dungeness crab exoskeleton)

Carassius auratus (*see* Goldfish)

Carbohydrates (*see* Glucose; Glycogen; Saccharides; Sugars)

Carbon, particulate (*see* Matter, particulate)

Carbon dioxide (*see also* Carbonate; Respiration)
J 28(9): 1303 (effect of accumulation on walleye photic behaviour)
(9): 1342 (measuring production in tilapia)

Carbonate; Bicarbonate (*see also* Hardness of natural waters)
J 28(1): 73 (thermal springs, Mt. Rainier National Park, USA)
(2): 171, 189, 203 (in waters of many small NW Ont. lakes)
(11): 1811 (tolerance of freshwater fishes to alkalinity in eutrophic Nebraska lakes & ponds)
A 199 (calcium carbonate re Gulf of St. Lawrence marine sediment geology)

Carcharodon carcharias (*see* Shark, white)

Carcinides maenas (*see* Crab, green)

Careproctus longipinnis (*see* Snailfish, longfin)
reinhardi (*see* Tadpole, sea)

Carotene; Carotenoids (*see* Pigments)

Carp (*Cyprinus carpio*)
J 28(7): 957 (vulnerability to northern pike predation)
(7): 1057 (effect of warm water of nuclear power plant discharge canal)
(7): 1061 (practical drying apparatus for fillets & steaks)
(9): 1345 (migration through brackish coastal waters, B.C.)
T 261 (bibliography for Gulf of St. Lawrence)
A 200 (mercury contamination in Red R., Sask.)
201 (mercury contamination in Great Lakes)

Carrothers, Percival John Godber
T 264 (fluid mechanics of netting and low solidity screens. 1. Apparatus, experimental method, and basic data)

Carson, William Victor
T 217 (petroleum oils in aquatic environment)

Casein
S 1531 (interaction with polyethylenimine, re flocculating power & removal of pollutants)

Castell, Charles Howell
J 28(1): 1 (DMA in muscle of gadoid fish)

Catabolism (*see also* Metabolism)
S 1491 (fission of phenylalanine aromatic ring by several classifications of algae)

Catalase (*see* Enzymes)

Catches; Catch effort (*see also* Angling; Fisheries; Yield)
J 28(3): 351 (sport vs. maritime commercial fisheries utilization rates of Miramichi R., N.B., salmon)
(3): 417 (1956–1965 commercial, of Pac. ocean perch by Oregon, Washington, & B.C. trawlers)

(8): 1211 (advantages & limitations of fishery catch & effort mathematical models)
B 175 (commercial, of oysters in Maritime Provinces & USA)
CJG 18: 1 (Nfld herring purse-seining, 1965–1970)
CNG 91 (steelhead trout age & size, in Vancouver Is. stream angling)
T 210, 221, 269 (during B.C. groundfish surveys)
213 (during B.C. offshore herring surveys)
216, 257 (summary of B.C. & U.S. Pac. coast commercial trawling, also catches per unit effort, 1969, 1970)
246 (bibliography of N America Pac. coast trawling)
250 (computer programming fish catch data)
270 (various breakdowns of Canadian Atl. salmon)
S 1492 (per unit effort, of haddock off Digby, N.S.)
1493 (commercial landings by countries, re Atl. cod trawl mesh size)
1540 (per unit effort assessments for ICNAF Subareas 2 & 3 major cod stocks)
1541 (American plaice fishery trends in ICNAF Subarea 3)
A 192 (N Atl. salmon by countries, 1961–67)
204 (experimental, of salmons & steelhead trout during INPFC studies, 1965)
207 (Atl. herring, N.B. & N.S., 1961–69)

Catfish, channel (*Ictalurus punctatus*)
J 28(1): 113 (sampling muscle for anesthetic residues)
(4): 613 (esterase properties of blood plasma)
(5): 783 (slime as bacterial medium re keeping quality)
(7): 957 (vulnerability to northern pike predation)
A 201 (mercury contamination in Great Lakes)

Catfish, white (*Ictalurus catus*)
J 28(7): 1507 (effect of warm water of nuclear power plant discharge canal)

Catheterization
J 28(5): 781 (improved vascular procedure for Salmonidae)

Catostomus catostomus (*see* Sucker, longnose)
commersoni (*see* Sucker, white)
macrocheilus (*see* Sucker, largescale)

Cayuga Lake, New York
J 28(5): 776 (*Pontoporeia affinis* amphipod caloric & lipid content)

Census (*see also* Abundance; Angling; Populations)
J 28(5): 755 (whelping harbour seals, Sable Is., N.S.)
T 224 (computer programming ringed seal population data)

Centrales
J 28(2): 265 (dominant diatom group in many small NW Ont. lakes)

Centroscyllium fabricii (*see* Dogfish, black)

Cephalins
S 1474 (fatty acid composition, in rainbow smelts)

Cephalopoda (*see also* Octopus; Octopuses; Squid; Squids)
S 1546 (NW Atl. resources & fisheries possibilities)

Ceratius holboelli (*see* Angler, deepsea)

Cercariae (*see* Flukes)

Ceriantharia (*see* Sea anemones)

Cestoda (tapeworms)
J 28(1): 31 (*Fistulicola plicatus* in N Atl. swordfish)
(10): 1385 (various Polychaeta as intermediate hosts of)
T 160 (*Scolex pleuronectes* in *Lepidion eques* morid fish)
S 1520 (*Hepatoxylon trichiuri* from giant squid, Nfld., as clue to squid's feed)
A 181 (*Eubothrium crassum* as parasitic indicator of geographical origin of Atl. salmon stocks)
224 (*Triaenophorus crassus* incidence in northern pike, whitefish, & cisco, Heming L., Man.; also incidence of Cestoda in N American, USSR, & European coregonids)

Cetacea (*see* Dolphin; Porpoise; Whale)

Cetorhinus maximus (*see* Shark, basking)

Chaetognatha (arrow worms)
J 28(7): 971 (*Sagitta elegans* life history, ecology, & mathematical model of population, St. Margaret's Bay, N.S.)
T 266 (Frobisher Bay, Baffin Is., N.W.T.)

Chandler, Ross Allan
A 221 (20-million-year-old geological "catch")

Chaoborinae
J 28(2): 257 (in zoobenthos of 15 small NW Ont. lakes)

Chapman, Martin John
J 28(6): 879 (enolase from lobster)

Char (*see* Trout, lake)

Char, arctic (*Salvelinus alpinus*)
T 231 (N America distribution of anadromous & landlocked forms; taxonomy; biology; test production in Keyhole L., Canadian Arctic)
261 (bibliography for Gulf of St. Lawrence)

Char, lake (*see* Trout, lake)

Chatterton, Katherine
J 28(4): 606 (blood chemistry values for juvenile coho salmon)

Chau, Yiu Kee
S 1529 (trace elements and chlorophyll in L. Ontario)

Chawla, Vinod Kumar
S 1529 (trace elements and chlorophyll in L. Ontario)

Checklists (*see also* Fishes, lists of; Invertebrates)
J 28(10): 1407 (compendium of 504 species in 242 genera & 52 families of abyssmal polychaetous annelids)
B 176 (synopsis of Canadian arctic, Pac., & Atl. marine zooplankton)
S 1470 (distributional, of B.C. marine molluscs, from surveys since 1950)

Chedabucto Bay, N.S. (re 1969 Bunker C fuel oil spill)
J 28(9): 1327 (copepods tolerance to spill residues)
(12): 1912 (residues concentration in waters, Apr. 1971)
T 217 (nature of spill constituents)
S 1569 (contamination of aquatic animals)
A 223 (study of, & combating spill)

Chelae (*see* Claws)

Chelating agents (EDTA, etc.)
J 28(2): 209 (effects on photosynthesis when used with nutrients added to samples of lake waters)
T 258 (toxicity tests of trisodium nitrilotriacetate as detergent re pollution)
A 203 (not recommended as suppressor of fish odours)

Chemical composition (*see* Composition, chemical)

Cheng, Joseph Yim-hung
S 1491 (fission of phenylalanine by marine algae)

Chesapeake Bay, Maryland
J 28(6): 911 (particulate carbon:nitrogen relations)

Chile
J 28(8): 1077 (physical oceanographic features of 32 fiords & inlets, also of some adjacent waters)

Chilipepper (*Sebastes* (*Sebastodes*) *goodei*)
T 246 (bibliography)

Chilling (*see also* Ice; Refrigeration; Superchilling)
T 220 (effects of storing sockeye salmon in refrigerated sea water vs. ice on quality of canned product)
242 (as for T 220 above, using salt-fortified refrigerated sea water)
A 203 (resume of T 220 & T 242 above)

Chilton, Doris Elizabeth
T 259 (commercial landings of western Canadian rock sole)

Chin, Christopher
J 28(6): 879 (enolase from lobster)

Chionoecetes bairdi (*see* Crab, tanner)
opilio (*see* Crab, queen)
tanneri (*see* Crabs)

Chirolophis ascanii (*see* Warbonnet, Atlantic)

Chironomidae (*see also* Diptera; Insects, aquatic)
J 28(1): 35 (differences upstream & downstream of a dammed Ont. lake)
(2): 257 (of zoobenthos in 15 small NW Ont. lakes)
(6): 928 (in feed of fluffy & tidepool sculpins)
(11): 1683 (associations & species diversification, L. Ontario bays)
T 258 (toxicity tests of trisodium nitrilotriacetate detergent on, re pollution)
S 1532, 1533 (distribution in high mountain North Boulder Creek, Colorado)
1536 (deformed larvae of several species in L. Erie & Okanagan R. lakes, B.C., possibly a result of herbicide, insecticide or detergent pollution)
1543 (of Georgian Bay, L. Erie, & L. Ontario)
1588 (nomenclature & phylogeny of *Harnischia*)

Chittenden, Mark Eustace, Jr.
J 28(12): 1823 (oxygen requirements of striped bass)

Chloeia entypa (*see* Polychaeta)

Chloride (for general data re natural waters, *see* Limnology; Oceanography; Waters, natural)
J 28(5): 625, 635 (level changes in brook trout after handling, anesthetization, & surgery)

Chlorinity (of sea water) (*see also* Oceanography; Salinity)
S 1472 (phenosafranin indicator for titrations)

Chlorophyceae (*see* Chlorophyta)

Chlorophylls (*see also* Algae; Photosynthesis; Phytoplankton; Plankton; Production, primary)
J 28(2): 171, 189, 203 (*a* in waters of many small NW Ont. lakes)
(2): 203 (re photosynthesis as affected by added nutrients to samples of water from small NW Ont. lakes)

(2): 215 (*a* content of periphyton in 4 small NW Ont. lakes)
(2): 295 (re differences & similarities among small NW Ont. lakes)
(5): 790 (re photosynthesis as affected by nitrogen, phosphorus, & iron enrichment of N Pac. sea waters)
T 265 (*a*, *b*, & *c* in waters & ice, re primary production, Frobisher Bay, Baffin Is., N.W.T.)
S 1466 (re large-scale primary productivity studies in N Pac. Ocean)
1528 (chemical fate in 50,000,000-year-old shale from lake sediments)
1529 (distribution of *a* in L. Ontario, re distribution of trace elements)
1586 (25-hour budget of production, export & grazing, Bedford Basin, N.S.)

Chlorophyta (*see also* Algae; Phytoplankton; Plankton; Seaweeds)
J 28(2): 192, 215 (of several small NW Ont. lakes)
(11): 1763 (effect of nitrate & phosphate addition on abundance in small NW Ont. lake)

Choi, Paul Mun Keung
T 272 (PCB and other industrial halogenated hydrocarbons in the environment)

Cholesterol (*see* Sterols)

Choline derivatives
J 28(4): 613 (acetylcholine esterase activity of various fish plasmas; anticholinesterase activity of various pesticides)

Chondrococcus columnaris (*see* ***Columnaris*** disease)

Chondrophora (*see* Jellyfish)

Choquette, Laurent Paul Emile
J 28(3): 448 (subcutaneous fibroma in lake trout in Que.)

Chromatography (*Note*: This widely used procedure is no longer indexed separately; *see* materials to which it is applied)

Chromium derivatives
J 28(2): 277 (in sediments of 4 small NW Ont. lakes)
(5): 786 (in dressed Canadian fishes from industrial area lakes)
S 1529 (distribution in L. Ontario)

Chromobacterium (*see also* Bacteria)
J 28(10): 1511 (isolates associated with surfaces of hatching Pac. salmon eggs)

Chromosomes (*see also* Cytology; Genetics)
J 28(11): 1745 (diploid components of large & dwarf white suckers & of longnose sucker)

Chrosomus eos (*see* Dace, northern redbelly)

Chrysophyceae (*see also* Algae; Diatoms; Phytoplankton; Plankton)
J 28(2): 194, 215 (of several small NW Ont. lakes)
(11): 1763 (effect of nitrate & phosphate addition to abundance in small NW Ont. lake)
S 1491 (ability to cleave phenylalanine aromatic ring)
A 211 (*Monochrysis lutheri* for zooplankton grazing experiments)

Chub, creek (*Semotilus atromaculatus*)
J 28(1): 45 (populations upstream & downstream of a dammed Ont. lake)
(9): 1285 (methylmercury in N.B.)

Chub, flathead (*Hybopsis gracilis*)
J 28(10): 1645 (host to new trematode species, Alta.)

Chub, hornyhead (*Nocomis* (*Hybopsis*) *biguttatus*)
J 28(1): 45 (populations upstream & downstream of a dammed Ont. lake)

Chub, lake (*Couesius plumbeus*) (*Hybopsis plumbea*)
J 28(10): 1645 (host to new trematode species, Alta.)

Chub, river (*Nocomis* (*Hybopsis*) *micropogon*)
J 28(1): 45 (populations upstream & downstream of a dammed Ont. lake)

Chuba, Joseph V.
J 28(8): 1208 (killifish "hemagglutinogens")

Ciliata
J 28(3): 391 (ultrastructural & incomplete symbionts, taxonomy, & key, of red-water ciliate *Mesodinium*: review)
T 267 (Frobisher Bay, Baffin Is., N.W.T.)
S 1559 (culture characteristics & feed of *Uronema*)

Circulation (of blood) (*see* Blood; Gills; Hemoglobin; Respiration)

Circulation (of waters) (*see also* Currents; Eutrophication; Hydrography; Limnology; Oceanography; Tides; Transport, mass)
T 271 (patterns in Gulf of St. Lawrence, June 1968 & Sept. 1969)

Cirripedia (*see* Barnacles)

Cirrutulidae (*see* Polychaeta)

Cisco, lake (*Coregonus artedii*) (lake herring; tullibee)
J 28(6): 924 (larval growth & survival temperature requirements)
T 261 (bibliography for Gulf of St. Lawrence)
S 1591 (pristane & other hydrocarbons in commercial Canadian oil)
A 200, 201 (mercury contamination in various Canadian waters)
224 (parasites)

Citharichthys sordidus (*see* Sanddab, Pacific)
stigmaeus (*see* Sanddab, speckled)

Cladocera (*see also* Crustacea; Zooplankton)
J 28(2): 231, 245 (*Bosmina*, *Holopedium*, *Daphnia*, etc. common to many small NW Ont. lakes)
(2): 245 (vertical distribution & seasonal abundance in 2 small shallow NW Ont. lakes)
(3): 311 (of 146 W Canadian alpine & subalpine lakes & ponds)
(4): 559 (seasonal calorific values, from 3 small E Ont. lakes)
(5): 705 (biological magnification & degradation of insecticides by)

Clam, arctic wedge (*Mesodesma arctatum*)
B 177 (re paralytic shellfish poisoning, E Canada)

Clam, bar (*Spisula* (*Mactra*) *solidissima*)
B 177 (re paralytic shellfish poisoning, E Canada)

Clam, butter (*Saxidomus giganteus*)
J 28(11): 1789 (melanin distribution in, re retention of paralytic shellfish toxin, B.C.)

Clam, hardshell (*see* Quahaug, northern)

Clam, littleneck (Atlantic) (*see* Quahaug, northern)

Clam, ocean (*see* Quahaug, ocean)

Clam, razor (Atlantic) (*Ensis directus*)
B 177 (re paralytic shellfish poisoning, E Canada)

Clam, razor (Pacific) (*Siliqua patula*)
T 232 (breeding & growth, Queen Charlotte Is. & W coast Vancouver Is.)

Clam, softshell (Atlantic) (*Mya arenaria*)
J 28(1): 59 (DDT residues in N.B. & P.E.I.)
(5): 793 (yellow phosphorus concentration in body, N.S.)
(9): 1225 (cadmium toxicity tests)
B 177 (re paralytic shellfish poisoning, E Canada)
T 217 (pollution from petroleum oil spills)
S 1569 (determination of residual fuel oil contamination in)

Clam diggers' itch
A 58(F) (cause, control, & treatment)

Clam drill, greater (*Lunatia* (*Polinices*) *heros*) (moon shell; moon snail)
B 177 (re paralytic shellfish poisoning, E Canada)

Clams
J 28(2): 257 (*Pisidium conventus* & *P. casertanum* common in many small NW Ont. lakes)
S 1551 (development of postlarval *Macoma balthica* mantle organs, feeding, & locomotion)
A 221 (ancient, forming core of rock concretions, found later as "holed stones")

Clark, A. S.
J 28(4): 559 (freshwater zooplankton calorific values)

Clarke, William Craig
S 1526 (feedback mechanism in eels)

Classification (*see* Genera; Keys; Nomenclature; Phylogeny; Speciation; Species; Taxonomy)

Classification (cluster analysis) (*see also* Associations; Communities)
S 1580 (& ordination of many shallow-water benthic species, P.E.I.)

Claws
T 235 (role of chelae in lobster aggressiveness)
S 1465 (role in crayfish mating)
1555 (shuddering behaviour during green shore crab attempted male–male mating)

Clayton, James Wallace
J 28(7): 1005 (walleye malate dehydrogenase isozymes)

Cleansing (*see* Depuration; Disinfection; Washing)

Cleugh, Thomas Reginald
J 28(2): 129 (initial survey of FRB Experimental Lakes, NW Ont.)

Climate (*see also* Precipitation)
J 28(2): 142, 265 (of FRB Experimental Lakes Area, NW Ont.)
S 1476 (implementation of Canadian ocean engineering, chemical oceanography & geochemistry re climatology)

Clostridium botulinum (*see* Botulism)

Clupea harengus harengus (*see* Herring, Atlantic)
pallasi (*see* Herring, Pacific)

Cobalt derivatives
J 28(2): 277 (in sediments of 4 small NW Ont. lakes)
(5): 643 (^{60}Co for irradiation of bacteria in smoked fish)
S 1529 (distribution in L. Ontario)
A 232 (^{60}Co as marine radioactive pollutant)

Coble, Daniel W.
J 28(7): 957 (northern pike predation)

Cod, arctic (*Boreogadus saida*)
T 261 (bibliography for Gulf of St. Lawrence)
266 (Frobisher Bay, Baffin Is., N.W.T.)

Cod, Atlantic (*Gadus morhua*)
J 28(1): 1 (dimethylamine production in dark muscle during frozen storage)
(1): 59 (DDT residues in N.B.)
(7): 935 (regular component of Passamaquoddy Bay fish communities, N.B.; length frequencies)
(7): 947 (blood pathways effects on blood-pressure drop in gills)
(8): 1125 (purines changes in iced fillets)
(9): 1285 (methylmercury in Bay of Fundy & N.S. Banks)
T 225 (associated with Bay of Fundy scallop beds)
260 (standing crop, availability, lengths, weights, etc., from Scotian Shelf surveys, 1958–68)
261 (bibliography for Gulf of St. Lawrence)
272 (halogenated hydrocarbon residues detected in)
S 1489 (binding affinities of blood proteins for sex hormones & corticosteroids in)
1493 (assessment of effects of trawl mesh size increases)
1540 (catch–effort assessments for ICNAF Subareas 2 & 3 major stocks)
1591 (pristane & other hydrocarbons in commercial Canadian liver oil)
A 181, 182 (ICNAF 1969 Canadian research summaries; also (181) parasite indicators of geographical origin of stocks)
194, 195 (Nfld. & Labrador)
200 (mercury contamination)

Cod, black (*see* Sablefish)

Cod, longfin (Pacific) (*Antimora rostrata*)
T 221 (taken in B.C. groundfish surveys)

Cod, Pacific (*Gadus macrocephalus*)
J 28(6): 883 (salinity, temperature, & dissolved oxygen effects on egg development re geographical distribution)
(8): 1071 (sodium chloride effects on *Clostridium botulinum* growth & toxin production in flesh homogenates)
T 216, 257 (catches during B.C. & U.S. Pac. coast commercial trawling, 1969, 1970)
221 (catches during B.C. groundfish surveys)
246 (bibliography)

Cods (Gadidae) (*see also* Burbot; Cod; Hake; Pollock; Tomcod)
T 246 (bibliography)

Coelenterata (*see also* Jellyfish)
T 225 (associated with Bay of Fundy scallop beds
266 (Frobisher Bay, Baffin Is., N.W.T.)
S 1532 (*Hydra* of a high mountain brook, Colorado)

Cohorts (*see also* Populations)
J 28(10): 1573 (mathematical models re animal production–biomass ratio)

Cold storage (*see also* Chilling; Freezing; Refrigeration)
S 1461 (thermistor readout monitoring system for temperatures)

Coleoptera (*see also* Insects, aquatic)
J 28(6): 849 (samplings from shallow stream bed)

Collecting, of specimens (*see also* Sampling; Trap)
J 28(8): 1209 (2 simple durable epifaunal collectors)

Collembola
S 1522 (*Podura aquatica* in a high Colorado mountain creek)

Collins, John Joseph
J 28(12): 1857 (transfer of salmon eggs)

Colour; Coloration (*see also* Pigments)
J 28(2): 171, 295 (of waters of small NW Ont. lakes, re similarities & differences among the lakes)

Columnaris disease (from *Chondrococcus columnaris*)
J 28(4): 553 (Columbia R. fish ladders influence on)
(9): 1253 (young rainbow trout & coho salmon antibody production & immunity responses; also vaccination)
(11): 1731 (factors re rainbow trout & chinook salmon susceptibility to)

Colus stimpsoni (*see* Spindle shell)

Communities (*see also* Associations; Populations)
J 28(2): 215 (epilithic diatoms in 4 small NW Ont. lakes)
(2): 231 (crustacean plankton in 45 small NW Ont. lakes)
(3): 311 (planktonic Crustacea in 146 W Canadian alpine & subalpine lakes & ponds)
(7): 935 (fish: seasonal components in Passamaquoddy Bay, N.B., re communities in warmer waters)
(11): 1683 (benthic macroinvertebrates, L. Ontario bays)
(11): 1715 (metabolism of benthic macroinvertebrates, L. Ontario bays)
(11): 1733 (production potential of seaweed–lobster community, St. Margaret's Bay, N.S.)

S 1532 (invertebrates in high mountain North Boulder Creek, Colorado)

Como Creek, Colorado
S 1577 (two new dinoflagellate species & associated microflora)

Compendium (*see* Checklists)

Competition (*see* Aggression; Feed)

Composition, chemical (*see also* Acids, amino; Acids, fatty; Analysis methods (chemical); Limnology; Nutrients, aquatic; Oceanography; Waters, natural)
J 28(1): 7 (seasonal changes in freshwater triclad flatworm *Dugesia tigrina*)
(2): 129, 171, 203 (many small NW Ont. lakes water)
(2): 215 (periphyton in 4 small NW Ont. lakes)
(2): 277 (sediments in 16 small NW Ont. lakes)
(3): 369 (sockeye salmon by X-ray spectrometric & multivariant analysis as indicator of geographic sources)
(4): 587 (of water in rainbow trout acclimation tanks)
(4): 606 (juvenile coho salmon blood)
T 200 (multiple discrimination analysis of data from J 28(3): 369 reference above)
217 (petroleum oils re determining origin of polluting spills)
246 (N America Pac. coast trawled fishes: bibliography)

Computer programming (*see also* Mathematical treatment of data; Models, mathematical)
J 28(1): 102 (plotting bathythermograph transect data on a printer)
(3): 443 (migration capture–recapture stochastic model)
(3): 446 (electronic processing of fishery research acoustical data)
(4): 573 (fry enumeration in streams)
T 209 (storage & retrieval of indexed & annotated bibliographical references)
212 (multiple discrimination analysis of X-ray spectroscopic data)
224 (analysis of ringed seal population data)
235 (agonistic behaviour of lobsters)
244 (multivariate analysis for fisheries biology)
250 (principle & operation of fish catch & pollution information system)

Condition
B 178 (of raft-cultured Pac. oyster in B.C.)

Conductivity, electrical
J 28(2): 129, 183 (of waters of many small NW Ont. lakes)

Connolly, G. F.
J 28(11): 1815 (dispenser for oxygen reagents)

Conover, Robert James
J 28(9): 1327 (relation of zooplankton & oil following wreck of tanker *Arrow*)
S 1482 (study of eutrophicated marine basin)
1586 (effect of plankton grazing in small marine basin)

Conservation (*see* Ecology; Management; Pollution)

Consumption of fish & fish products as food for man (*see* Food)

Contracaecum aduncum (*see* Nematoda)

Cooking; Precooking (*see also* Canning; Quality of fishery products)
B 177 (effects on paraiytic shellfish toxin in clams, etc.)
T 249 (detecting marine oil adulteration of all-vegetable margarine & cooking fats)
A 203 (precooked fish in batter)

Cooling (*see* Chilling; Ice; Refrigeration; Seawater, refrigerated)

Coombs, J. F.
J 28(12): 1883 (Manitoulin lakes limnology)

Coote, Arthur Renton
J 28(11): 1815 (dispenser for oxygen reagents)

Copelata
T 266 (Frobisher Bay, Baffin Is., N.W.T.)

Copepoda (*see also* Crustacea; Zooplankton)
J 28(1): 23 (*Calanus finmarchicus* re *C. glacialis* adult male taxonomy)
(2): 231, 245 (*Tropocyclops*, *Mesocyclops*, *Cyclops*, *Senecella*, *Limnocalanus* & *Diaptomus* species common in many small NW Ont. lakes)
(2): 245 (vertical distribution & seasonal abundance in 2 small shallow NW Ont. lakes)
(3): 311 (of 146 W Canadian alpine & subalpine lakes & ponds)
(3): 323 (*Lepeophtheirus* species parasitic to ocean sunfish: taxonomy & nomenclature re *Dentigryps*)
(4): 559 (seasonal calorific content, from 3 small E Ont. lakes)
(6): 928 (differential consumption of, by tidepool vs. fluffy sculpins cohabiting in tide pools)
(8): 1143 (*Lepeophtheirus salmonis*, & *Caligus clemensi* locomotory mechanisms)
(9): 1327 (tolerance of *Calanus finmarchicus* & *Temora longicornis* to fuel oil, & their fecal sedimentation of oil)
(10): 1563 (2 new species & 1 new record of *Holobomolochus*; 2 new hosts of *Bomolochus cuneatus*)
T 160 (parasitic to *Lepidion* fishes)

248 (*Calanus pacificus* culture & grazing on diatoms, re productivity)
252 (biomass off N.S. coast)
266 (Frobisher Bay, Baffin Is., N.W.T.)
S 1485 (importance & general implications of organic matter in aquatic environments re filter-feeding of)
1496 (new parasitic genus & species: *Proclavellodes pillaii*, from S India)
1499 (redescription of *Caligus rapax*)
1501 (*Haemobaphes* in B.C. waters, including a new species *H. intermedius*; *also H. diceraus*)
1566 (new species *Lernanthropus togatus* parasitic to gills of marine Kenyan fish *Gaterin*)
1568 (Eudactylinidae & Pseudocycnidae parasitic on Australian fishes)
A 211 (*Calanus plumchrus* & *Pseudocalanus minutus* re juvenile Pac. salmon feed)

Copper derivatives
J 28(5): 655 (long-term effects of sulphate concentrations on brook trout adults, spawning, eggs, & fry)
(5): 786 (in dressed Canadian fishes from industrial area lakes)
(6): 843 (level in P.E.I. oysters)
T 202 (diatoms as indicators of, and effects of, in NW Miramichi R. basin, N.B.)
S 1529 (distribution in L. Ontario)
1553 (re mining effluent effects on NW Miramichi R. vascular plants)
A 222 (avoidance reaction sensitivity to sub-lethal levels by Atl. salmon & brook trout)

Copulation) *see* Mating; Reproduction)

Corals
T 225 (associated with Bay of Fundy scallop beds)

Coregonids (*see also* subclassifications)
T 151 (bibliography of)
A 224 (world distribution; parasites of many European *Coregonus* species)

Coregonus artedii (*see* Cisco, lake)
clupeaformis (*see* Whitefish, lake)
world distribution & parasites (*see* A 224)

Corer
J 28(3): 365 (simple corer vs. Ekman grab for sampling shallow-water benthos)

Cormorant, common (*Phalacrocorax carbo*)
T 272 (halogenated hydrocarbon residues detected in body)

Cormorant, double crested (*Phalacrocorax auritus*)
T 272 (halogenated hydrocarbon residues detected in eggs)

Cornick, John Walter
CHN 40 (gaffkemia & storage temperatures re red crab)
41 (gaffkemia among stored lobsters)
42 (gaffkemia control in lobster storage facilities)

Corrections
J 28(8): 1219 (to recent articles in this Journal)

Cortisol; Cortisone (*see also* Hormones; Steroids)
J 28(4): 477, 485 (histological effects on various tissues of gonadectomized sockeye salmon)

Coryphaena hippurus (*see* Dolphin)

Coryphaenoides rupestris (*see* Grenadier)

Cottidae (*see* Cabezon; Sculpin; Sculpins)

Cottunculus microps (*see* Sculpin, polar)

Cottus bairdi (*see* Sculpin, mottled)
rhotheus (*see* Sculpin, torrent)

Couesius plumbeus (*see* Chub, lake)

Counting; Enumeration
J 28(4): 573 (technique for stream-migrating kokanee fry; also computer programming of data)
(7): 1035 (quick statistical methods for analyzing digital echo fish count sequences)
T 215 (photo-electric fish counter)
S 1503 (suspended particles in sea water with Coulter counter)

Courtship (*see also* Mating; Reproduction; Spawning)
S 1535 (chinook salmon gonadotropin effect on sexual behaviour of hypophysectomized & gonadectomized female guppies)

Cow (*Bos typicus primigenius*)
J 28(8): 1173 (glycoproteins constituents levels of blood sera re those of Pac. salmons & trouts)

Cowley, Leonard Joseph
T 254 (phosphorus levels in Nfld. water)

Cox, Robert Edwin
S 1528 (geological fate of chlorophyll)

Crab, box (*Lopholithodes mandtii*)
T 210 (taken during B.C. trawl surveys)

Crab, deep- sea red (*Geryon quinquedens*)
CHN 40 (recommended live storage temperatures; resistance to gaffkemia lobster disease)
S 1527 (muscle sterols)

Crab, Dungeness (*Cancer magister*)
J 28(8): 1191 (amino acid & fatty acid composition of tissues)
T 257 (taken in 1970 B.C. trawl fishery)
A 200 (mercury contamination, B.C.)

Crab, green (*Carcinides maenas*)
J 28(9): 1225 (cadmium toxicity tests)
S 1527 (muscle sterols)

Crab, green shore (*Hemigrapsus oregonensis*)
S 1555 (claw-shuddering behaviour during attempted male–male mating)

Crab, Jonah (*Cancer borealis*)
S 1527 (muscle sterols)

Crab, queen (*Chionoecetes opilio*) (snow crab)
J 28(4): 509 (wastes carotenoids; also as feed to improve brook trout pigmentation)
T 204 (tag recaptures & movements of male, Gaspe region of Gulf of St. Lawrence)
S 1527 (muscle sterols)
A 217(F) (synopsis of biology & fishery)

Crab, rock (*Cancer irroratus*)
J 28(9): 1285 (methylmercury in, off N.S.)
T 217 (pollution from petroleum oil spills)
S 1527 (muscle & egg sterols)
1569 (determination of residual fuel oil contamination in)

Crab, snow (*see* Crab, queen)

Crab, tanner (*Chionoecetes bairdi*)
T 257 (taken in B.C. trawl fishery, 1970)

Crab, toad (*Hyas araneus*)
S 1527 (muscle & egg sterols)

Crabmeal (*see also* Fishmeal)
J 28(4): 509 (for feeding brook trout to improve pigmentation)

Crabs
J 28(10): 1527 (several new distribution records, including *Chionoecetes tanneri*, in or to B.C.)
T 255 (associated with Bay of Fundy scallop beds)
S 1527 (*Erimacrus isenbeckii* (Japanese) muscle sterols)
A 200 (mercury contamination of B.C. & Canadian Atl. coastals)

Crabs, hermit (Anomura)
J 28(9): 1225 (cadmium toxicity tests)
(9): 1285 (methylmercury in *Pagurus* off N.S.)
(10): 1527 (20 new distribution records & 3 new species, *Pagurus caurinus*, *P. quaylei* & *P. stevensae*, in B.C.)
S 1527 (*Pagurus longicarpus* & *P. bernhardus* muscle & egg sterols)
1569 (determination of residual fuel oil contamination in)

Craig, Peter C.
J 28(1): 115 (meristic differences in *Salvelinus alpinus*)

Crangon septemspinosa (*see* Shrimp, sand)

Crangonyx richmondensis occidentalis (*see* Amphipoda)

Crania californica (Brachiopoda)
T 268 (in B.C. faunistic surveys since 1960)

Crappie, black (*Pomoxis nigromaculatus*)
J 28(7): 957 (vulnerability to northern pike predation)

Crappie, white (*Pomoxis annularis*)
J 28(7): 957 (vulnerability to northern pike predation)

Crassostrea gigas (*see* Oyster, Pacific)
virginica (*see* Oyster, Atlantic)

Crayfishes (freshwater)
S 1465, 1468, 1486 (*Pacifastacus trowbridgii* copulatory, egg-laying, & maternal–offspring behaviour)
1527 (muscle sterols)
1557 (temperature & photoperiod effects on *Orconectes virilis* ovarian maturation & egg-laying)

Creaser, Edwin Philip, Jr.
J 28(7): 1049 (water-sampling receptacle for mud flats)

Cressoniella montana (*see* Diptera)

Cristispira (spirochaete)
S 1469 (occurrence in 12 of 62 W Canada marine bivalve species)

Cristivomer namaycush (*see* Trout, lake)

Crop, standing
J 28(5): 711 (of 2 amphipod species, Marion L., B.C., re bioenergetics & secondary production)
T 260 (Scotian Shelf groundfishes)

Cross, Ford A.
J 28(11): 1783 (distribution of radioactive zinc in marine ecosystem)

Crustacea (*see also* subclassifications and names of species)
J 28(1): 35 (differences upstream & downstream of a dammed Ont. lake)
(2): 231 (communities in plankton of 45 small NW Ont. lakes)

(2): 245 (vertical distribution & seasonal abundance in 2 shallow NW Ont. lakes)
(3): 311 (planktonic, of 146 W Canadian alpine & subalpine lakes & ponds)
(4): 509 (shrimp & crab processing wastes for trout feed)
(6): 928 (in feed of fluffy & tidepool sculpins)
(11): 1683 (benthic macroinvertebrates associations & species diversity, L. Ontario bays)
T 225 (associated with Bay of Fundy scallop beds)
S 1527 (flesh sterols of 14 species; egg sterols of 3 species)
1567 (as enemies of fishes, re diseases)
A 224 (parasitic to N American, USSR, & European coregonid fishes)

Cryo-preservation (*see* Superchilling)

Cryptacanthodes maculatus (*see* Wrymouth)

Cryptochironomus (Chironomidae)
S 1588 (re synonymy with *Harnischia*)

Cryptocladopelma (Chironomidae)
S 1588 (re synonymy with *Harnischia*)

Cryptophyceae
J 28(2): 195 (of several small NW Ont. lakes)
S 1491 (ability to cleave phenylalanine aromatic ring)

Cryptopsaras couesi (*see* Angler, lesser deepsea)

Ctenophora
T 266 (Frobisher Bay, Baffin Is., N.W.T.)

Culaea inconstans (*see* Stickleback, brook)

Culex pipiens (*see* Mosquito)

Cultch (*see* Culture)

Culture (invertebrates) (*see also* Bacteria)
B 177 (*Gonyaulax tamarensis* re paralytic shellfish poisoning)
178 (re raft culture of Pac. oysters in B.C.)
T 248 (*Calanus pacificus* copepod fed diatoms)
262 (utilizing warm effluent from steam-electric power plants)
S 1559 (characteristics of *Uronema* ciliate)
A 211 (re primary & secondary biomass feed production)
213 & 213(F) (artificial rearing of lobsters)

Culture (vertebrates) (*see also* Hatcheries; Feed; Rations)
J 28(4): 517 (first vibriosis records in Canadian cultured Pac. salmons; correction on J28(8): 1219)
(8): 1113 (calorie-to-protein ratio for brook trout rations)
T 165(F) (rainbow trout farming in central Canada)
222 (mariculture re genetics)
236 (mud dab eggs & larvae)
243 (sablefish: progress in 1970)
262 (utilization of warm effluent from steam-electric power plants)
S 1502 (automatic wet-feed dispenser for salmonids)
A 211 (pink salmon eggs)
214 (fish farming; sex hormones to delay or accelerate maturation)

Cumberland Sound, Baffin Island, N.W.T.
J 28(9): 1309 (white whale growth, reproduction, & behaviour)

Cunner (*Tautogolabrus adspersus*)
T 255 (yellow phosphorus toxicity tests)
261 (bibliography for Gulf of St. Lawrence)

Cunningham, Carl Cleveland
S 1473 (phenosafranin indicator for chlorinity titrations)

Curd (in canned products)
T 220 (effects of storing sockeye salmon in ice vs. refrigerated sea water, on incidence of)

Cured fish products (*see* Drying)

Curl, Herbert, Jr.
J 28(5): 790 (influence of nutrient enrichment on N Pac. phytoplankton)

Currents, marine (*see also* Hydrography; Oceanography; Tides; Transport, mass)
J 28(10): 1403 (re amphipacific distribution of polychaetes)
T 219 (St. Margaret's Bay, N.S.)
253 (velocity program & examples of records, from moored meters in Strait of Georgia, 1968–70)
271 (Gulf of St. Lawrence circulation patterns, June 1968 & Sept. 1969)
S 1539 (re capacity of marine estuaries to accept pollutants; use of dyes to follow flushing action)

Cusk (*Brosme brosme*)
J 28(1): 1 (dimethylamine formation in dark muscle during frozen storage)
T 225 (associated with Bay of Fundy scallop beds)
260 (standing crop, availability, lengths, weights, etc. from Scotian Shelf surveys, 1958–68)
261 (bibliography for Gulf of St. Lawrence)

Cyanide
T 255 (toxicity tests in brook trout)

Cyanophyta (*see also* Algae; Phytoplankton; Plankton)
J 28(2): 192, 215 (of several small NW Ont. lakes)
S 1491 (ability to cleave phenylalanine aromatic ring)

Cyclops bicuspidatus thomasi (*see* Copepoda)

Cyclopterus lumpus (*see* Lumpfish)

Cyclotella
J 28(2): 265 (dominant diatoms in many small NW Ont. lakes)

Cyclothone microdon (*see* Anglemouth, veiled)

Cyclotrichium meunieri (a ciliate) (*see also Mesodinium*)
J 28(3): 391 (proposed change to genus *Mesodinium*)

Cymatogaster aggregata (*see* Perch, shiner)

Cyprina islandica (*see* Quahaug, ocean)

Cyprinodon variegatus (*see* Minnow, sheepshead)

Cyprinus carpio (*see* Carp)

Cystophora cristata (*see* Seal, hooded)

Cytology (*see also* Chromosomes; Genes; Histology)
J 28(1): 104 (proteolytic pseudomonad causing rainbow trout skin lesions)
(10): 1511 (of bacteria associated with surfaces of hatching Pac. salmon eggs, re egg mortality)
(11): 1745 (diploid components of chromosomes; karyotypes; of dwarf & large white suckers & of longnose sucker)
(11): 1733 (acid phosphatase activity in *Clostridium botulinum* vegetative cells & spores)
B 177 (*Gonyaulax tamerensis* dinoflagellate re paralytic shellfish toxicity)
S 1559 (*Uronema* marine ciliate)
1589 (*Dinoasteromonas* flagellates re discoasters)

Cytophaga (*see also* Bacteria)
J 28(10): 1511 (associated with surfaces of hatching Pac. salmon eggs)

Cytotaxonomy
S 1589 (Dinoasteromonadacea flagellates)

D

2,4-D (*see* Herbicides)

Dab, mud (*Limanda yokohamae*)
T 236 (egg & larvae culture, development, growth, etc.)

Dace, blacknose (*Rhinichthys atratulus*)
J 28(1): 45 (populations upstream & downstream of a dammed Ont. lake)

Dace, longnose (*Rhinichthys cataractae*)
J 28(1): 45 (populations upstream & downstream of a dammed Ont. lake)
(10): 1645 (host to new trematode species, Alta.)

Dace, northern redbelly (*Phoxinus* (*Chrosomus*) *eos*)
J 28(1): 45 (populations upstream & downstream of a dammed Ont. lake)

Dahlberg, Michael Lee
J 28(8): 1107 (computer simulation of pollution minnow deaths)

Dales, Rodney Phillips
J 28(10): 1487 (bioluminescence in pelagic polychaetes)

Damalichthys vacca (*see* Perch, pile)

Dambergs, Nikolajs
CHN 39 (extraction of isopropanol in fish protein concentrates)

Dams
J 28(1): 35, 45 (differences in benthos & fish populations upstream & downstream of a dammed Ont. lake)

Danielson, Jakob
A 228 (Greenlandic painter: book review)

Daphnia (*see* Cladocera)

Darkness (*see also* Light, reactions to)
S 1557 (effect on crayfish ovarian maturation & subsequent egg-laying ability)

Darter, johnny (*Etheostoma nigrum*)
J 28(7): 1507 (effect of warm water of nuclear power plant discharge canal)

Dasyatis centroura (*see* Stingray, roughtail)

Davenport, Douglas
T 221 (*G. B. Reed* groundfish cruise 70–3)
269 (*G. B. Reed* groundfish cruise 71–1)

Davies, Ronald Wallace
J 28(4): 543 (freshwater Hirudinoidea key)

Davis, John Christopher
J 28(10): 1609 (circulatory and ventilatory responses of trout)

Davis, Robert Maurice
J 28(4): 505 (Atl. salmon histological comparisons)

Day, Dwane
T 246 (Pac. trawl fishery & groundfish)

DDD; DDE; DDT (*see* Insecticides)

Deaminase (*see* Enzymes)

Decapoda (*see also* subclassifications and common names)
J 28(5): 705 (biological magnification & degradation of insecticides by fresh water)
(6): 928 (in feed of fluffy & tidepool sculpins)
T 266 (Frobisher Bay, Baffin Is., N.W.T.)
S 1527 (sterols of several types of)

Decomposition (*see* Bacteria; Quality of fishery products)

Defecation (*see* Feces)

Defense mechanisms (*see* Disease)

Deformity (*see* Abnormality)

Dehydrogenases (*see* Enzymes)

De Lange Boom, Bodo Rudolf
T 253 (velocity and water temperature records, Strait of Georgia)

Delolepis gigantea (*see* Wrymouth, giant)

Delphinapterus leucas (*see* Whale, white)

Denaturation
S 1509 (accelerated, of rabbit & trout myosin in frozen solution)
A 203 (free fatty acids role re frozen fish)

Density; Specific gravity (*Note:* For general data re natural waters, *see* Limnology; Oceanography)

Dentigryps (parasitic copepods)
J 28(3): 323 (species transferred to genus *Lepeophtheirus*)

Deoxyribonuclease (*see* Enzymes)

Deoxyribonucleic acid (DNA) (*see* Acids, nucleic; Nucleosides)

Depth (for distribution of organisms, *see* Benthos; Distribution; for depths and effects of, *see* Hydrodynamics; Oceanography)

Depuration
B 177 (of E Canada shellfish re paralytic shellfish toxicity)

Derksen, Arthur John
J 28(8): 1133 (migrations of walleyes)

Dermatitis, schistosome
A 58(F) (cause, control, & treatment of human "swimmers' itch" & "clam diggers' itch")

Derzhavin's biostatistical method of population analysis
J 28(10): 1666 (examples)
S 1582 (population dynamics)

Desai, Indrajit Dayalji
S 1480 (composition of a unicellular red alga)

Deshmukh, Diwakar Shankarrao
J 28(6): 843 (zinc retention in young rats fed increasing levels of high-zinc oysters)

Desmosterol (*see* Sterols)

Desulfovibrio desulfuricans (*see* Bacteria)

Detergents (*see* Nitrilotriacetate, trisodium; Phosphates; Pollution)

Detoxification (*see* Depuration)

Detritus (*see* Matter, particulate; Sediments)

Development (*see also* Growth; Maturity; *also* names of organisms)
J 28(1): 95 (tail length re respiration mode in big skate larvae)
(3): 379 (dissolved oxygen requirements for embryonic & larval northern quahaug)
(5): 727 (salinity & temperature effects on embryonic petrale sole)
(6): 883 (environmental effects on Pac. cod eggs, re geographical distribution)
(7): 1051 (white seaperch, Tomales Bay, Calif.)
(10): 1545 (salinity & temperature effects on Pac. herring early)
T 236 (mud dab eggs & larvae)
S 1486 (behaviour of female crayfish towards newly hatched young)
1590 : 552 (of fishes re temperature)

Diaphanosoma (*see* Cladocera)

Diaptomus (*see also* Copepoda)
J 28(2): 231, 245 (*D. minutus* common in many small NW Ont. lakes)
(3): 311 (*D. articus* dominant in many W Canadian alpine & subalpine lakes & ponds)

Diatoms (*see also* Phytoplankton)
J 28(2): 194, 215, 265 (of several small NW Ont. lakes)
(2): 265, 295 (of sediments in 16 small NW Ont. lakes as indicators of meteorological & limnological history of the lakes)

T 202 (169 species from NW Miramichi R., N.B., including many new Atl. provinces records; also their use as indicators of heavy-metal water pollution)
248 (as culture feed for *Calanus pacificus* in grazing experiments)
267 (Frobisher Bay, Baffin Is., N.W.T.)
S 1491 (ability to cleave phenylalanine aromatic ring)
1513 (as culture feed for *Calanus* in grazing experiments)

Dickie, Lloyd Merlin
S 1476 (marine science & technology)
A 196 (review of book on fisheries population dynamics)
197 (metabolism and biological production in fish)

Dickson, Ian William
J 28(4): 587 (factors influencing rainbow trout metabolism)

Dickson Lake, B.C.
J 28(9): 1259 (segregation between adult cutthroat & Dolly Varden trouts)

Diel habits (*see also* Behaviour; Light, reactions to)
J 28(4): 573 (stream-migrating kokanee fry)
(9): 1259 (Dolly Varden & cutthroat trouts in 3 B.C. lakes)
T 248 (*Calanus pacificus* grazing habits re marine productivity)
S 1513 (*Calanus* grazing habits re marine productivity)

Dieldrin (*see* Insecticides)

Diestothyris frontalis (Brachiopoda)
T 268 (in B.C. faunistic surveys since 1960)

Diet (*see* Culture; Feed; Feedstuff; Hatcheries; Predation; Rations)

Digenea (*see* Flukes)

Digestion; Digestive tract (*see also* Bioenergetics; Feed; Metabolism; Rations)
J 28(1): 110 (rate of sockeye salmon alevins in mountain whitefish stomach, & temperature effect on rate)
(3): 335 (vs. survival of sedimentary bacteria after ingestion by tubificid oligochaetes)
(10): 1635 (by young sockeye salmon re nature of diet)

Dill, Peter Arnott
J 28(9): 1319 (perception of light by young salmon)

Dimethylamine (DMA) (*see also* Amines; Trimethylamine)
J 28(1): 1 (formation vs. non-formation in stored frozen dark muscle of gadoid vs. non-gadoid Atl. coast fishes)

Dimond, John Barnet
J 28(12): 1877 (DDT in lotic ecosystem)

Dinamoebidium (*see* Dinoflagellates)

Dingle, John Reginald
J 28(8): 1125 (inosine phosphate breakdown in fishes)

Dinoasteromonadaceae (*see* Dinoflagellates)

Dinoasteromonas (*see* Dinoflagellates)

Dinoflagellates (*see also* Flagellates)
J 28(2): 195 (Peridineae of several small NW Ont. lakes)
B 177 (*Gonyaulax tamarensis* re paralytic shellfish toxicity)
T 267 (Frobisher Bay, Baffin Is., N.W.T.)
S 1488 (*Actiniscus canadensis* (new species), *A. pentasterias arcticus* (new variety), & *Pseudoactiniscus apentasterias* (new genus & species): marine relicts in Canadian arctic lakes)
1577 (*Dinamoebidium coloradense* & *Katodinium auratum* (2 new species) from Como Creek, Colorado)
1578 (*Dinamoebidium hyperboreum* (new species) from Ellesmere Is. coastal waters, N.W.T.)
1589 (taxonomy, cytotaxonomy & morphogenesis of new family Dinoasteromonadaceae; new genus *Dinoasteromonas;* new species *D. tribrachiatus, D. pentaradiatus, D. deflandrei, D. brouweri;* discoasters re morphology & taxonomy of fossil & recent Dinophyta)

Dinophyceae (*see also* Dinoflagellates)
S 1589 (fossil & contemporary, secreting discoasters)

Diodon holocanthus (*see* Balloonfish)
hystrix (*see* Porcupinefish)

Diptera (*see also* Chironomidae; Insects, aquatic)
J 28(1): 35 (differences upstream & downstream of a dammed Ont. lake)
(1): 73 (ecological energetics & natural history of *Hedriodiscus truquii* in thermal springs)
(2): 257 (in zoobenthos of 15 small NW Ont. lakes)
(5): 705 (biological magnification & degradation of insecticides by)
(6): 849 (samplings from shallow stream beds)
S 1532, 1533 (of a high Colorado mountain creek, including a new genus & species, *Cressoniella montana*)

Discinisca lamellosa (Brachiopoda)
T 268 (in B.C. faunistic surveys since 1960)

Discoasters
S 1589 (re morphology & taxonomy of fossil & comtemporary Dinophyta)

Disease (*see also* Cytology; Histology; Parasites; Pathology; Tumours; Viruses)
J 28(1): 112 (leukemic condition in cutthroat trout)
(4): 517 (first records of vibriosis in Pac. salmon cultured in Canada; correction on J 28(8): 1219)
(4): 533 (Columbia R. fish ladders influence on columnaris disease of fishes)
(7): 1064 (infectious pancreatic necrosis virus in brook trout feces & organs; effect of stress on detecting masked viral & bacterial infections in fishes)
(9): 1253 (*columnaris*, of rainbow trout & coho salmon; antibody production, immune responses, vaccination)
(9): 1350 (infectious pancreatic necrosis virus found in brook trout in 2 Ont. hatcheries)
(10): 1629 (first spontaneous furunculosis occurrence in a marine fish)
(11): 1739 (rainbow trout & chinook salmon susceptibility to *columnaris*)
(11): 1809 (new lymphocystis viral infection records in gobiid fishes & balloonfish, E Pac. coast)
CHN 40 (red crab resistance to gaffkemia lobster disease)
41, 42 (nature & control of gaffkemia in lobsters)
T 226 (*Aeromonas liquefaciens* bacteria cause of epizootic fish mortalities in NW Miramichi R., N.B.; possibility of shiners as immune carriers)
245 (uncertain, possibly fungal, of mountain whitefish & rainbow trout, Kootenay L., B.C.)
246 (bibliography of N America Pac. coast trawled fishes)
S 1487 (from effects of nematode parasitization on fishes)
1567 (re Crustacea as enemies of fish)
A 58(F) (human dermatitis from fluke larvae)
180 (gaffkemia & its pathology in lobsters)
186 (infectious, of USSR fishes; immunity & control: book review)

Disinfection; Disinfectants
J 28(12): 1899 (of rainbow trout & coho salmon fry resultant stress from formalin treatment)
CHN 42 (of lobster tanks & pounds against gaffkemia disease bacteria)
A 58(F) (against swimmers' & clam-diggers' dermatitis itch)
203 (refrigerated seawater equipment for holding fish)

Dispersal (*see also* Dispersants; Distribution)
J 28(7): 1019 (role of social behaviour in introduced rainbow trout dispersal)

Dispersants
S 1476 (combating fuel oil spills)
A 223 (combating fuel oil spills)

Distribution (biological) (*see also* Age; Marking; Migration; Species, new records or range extensions; Tagging)
J 28(1): 49 (of populations of 2 salamander species, Marion L., B.C.)
(2): 245 (vertical, of zooplankton in 2 shallow small NW Ont. lakes)
(3): 311 (of planktonic Crustacea in 146 W Canadian alpine & subalpine lakes & ponds)
(3): 323 (*Lepeophtheirus nordmanni* & *L. hastatus* parasitic copepods world distribution)
(3): 369 (salmonid elemental composition re geographical origins see also T 200 below)
(3): 391 (of red-water ciliate *Mesodinium rubrum*)
(3): 417 (bathymetric, re Pac. ocean perch reproductive patterns)
(3): 427 (tubesnout & prickleback species)
(3): 452 (world, of native or introduced brook trout)
(4): 465 (N American, re intraspecific variations of lake char)
(5): 663 (world, of rainbow trout)
(5): 749 (arctic grayling geographical origin)
(6): 883 (Pac. cod, re environmental effects on egg development)
(6): 911 (particulate carbon & nitrogen re primary production, Chesapeake Bay, Md.)
(9): 1259 (Dolly Varden & cutthroat trouts re feed in 3 B.C. lakes)
(10): 1403 (amphipacific, of some 25 polychaete species)
(10): 1663 (Pac. herring offshore, on basis of fur seal stomach contents; also of fur seals off B.C.)
(10): 1621 (northern rockfish)
B 177 (paralytic shellfish poison in E Canada shellfishes; geographical & anatomical)
CJG 18: 25 (seasonal, of NE Nfld. & Labrador herring)
T 200 (multiple discrimination analysis of data from J 28(3): 369 reference above)
213 (lateral & depth, of B.C. offshore herring)
221 (Pac. ocean perch as taken in B.C. groundfish surveys)
225 (Bay of Fundy benthos associated with sea scallop)
252 (herring larvae off S N.S. coast)
260 (depth, of Scotian Shelf groundfishes)
S 1470 (latitudinal & depth, in checklist of B.C. marine molluscs)

Abbreviations: J — *Journal.* B — *Bulletin.* AR — *Annual Report.* R — *Review. Circular Series*: CHN — Halifax; CNG — Nanaimo; CJG — St. John's. T — *Technical Reports.* MSP — *Miscellaneous Special Publications.* S — *Studies.* A — *Interpretive Articles.*

1529 (trace elements & chlorophyll *a* in L. Ontario)
1532 (invertebrates in high mountain North Boulder Creek, Colorado)
1580 (shallow-water marine benthos, Bideford R. estuary, P.E.I.)
1590 : 558 (of various fishes re temperature)
A 193 (world, of capelin)
204 (Pac. salmons & steelhead trout in N Pac. Ocean)
224 (world, of coregonid fishes & their parasites)

Distribution (physical)
T 262 (predicting excess temperature distribution in natural waters receiving hot discharge from steam-electric power plants)
A 232 (radioactive isotopes in atmospheric & marine environment from various sources)

DNA (deoxyribonucleic acid) (*see* Acids, nucleic; Nucleosides)

Doctor, fish (*Gymnelis viridis*)
T 261 (bibliography for Gulf of St. Lawrence)

Dodecaceria (cirrutulid polychaetes)
J 28(10): 1437 (list of 13 recognized species, plus a new species *D. berkeleyi*)

Dogfish, black (*Centroscyllium fabricii*)
T 261 (bibliography for Gulf of St. Lawrence)

Dogfish, Pacific (*see* Dogfish, spiny (Pacific))

Dogfish, spiny (Atlantic) (*Squalus acanthias*)
J 28(9): 1285 (methylmercury in, N.S. Banks)
T 260 (standing crop, availability, lengths, weights, etc. from Scotian Shelf surveys, 1958–68)
261 (bibliography for Gulf of St. Lawrence)

Dogfish, spiny (Pacific) (*Squalus acanthias*) (*S. suckleyi*) (dogfish shark)
T 210, 221, 269 (catches during B.C. groundfish surveys)
210 (size & sex composition, feed)
213 (size, feed, etc., taken during offshore B.C. herring surveys)
216, 257 (taken during B.C. & U.S. Pac. coast commercial trawling, 1969, 1970)
246 (bibliography)
S 1591 (pristane & other hydrocarbons in a commercial Canadian liver oil)

Dogwinkle, Atlantic (*Thais* (*Purpura*) *lapillus*)
B 177 (re paralytic shellfish poisoning, E Canada)

Dolly Varden (*Salvelinus malma*)
J 28(9): 1259 (sympatry & allopatry with cutthroat trout re feed & habits in 3 B.C. lakes)

Dolphin (*Coryphaena hippurus*)
J 28(7): 947 (blood pathways effects on blood-pressure drop in gills)
T 261 (bibliography for Gulf of St. Lawrence)

Dolphin, Amazon River (*Inia geoffrensis*)
S 1514 (wax esters, triglycerides & glyceryl ethers in jaw & blubber fats re echolocation)

Dominy, Charles Leslie
J 28(8): 1215 (blood changes in alewives through exercise)

Donaldson, Edward Mossop
S 1526 (feedback mechanism in eels)
1535 (sexual behaviour of female guppy)

Dorosoma cepedianum (*see* Shad, gizzard)

Drags (*see* Currents)

Drift (*see* Currents)

Drill, greater clam (*see* Clam drill, greater)

Drill, oyster (*see* Oyster drill, Atlantic)

Drilonereis falcata minor (*see* Polychaeta)

Drogues (*see* Currents)

Drum, freshwater (*Aplodinotus grunniens*) (sheepshead)
J 28(7): 1061 (practical drying equipment for fillets & steaks)
S 1591 (pristane & other hydrocarbons in commercial oil)
A 200 (mercury contamination, L. Winnipeg)
201 (mercury contamination, Great Lakes)

Drummond, George Ira
A 226 (nucleoside cyclic phosphate diesterases)
227 (nucleotide phosphomonoesterases)

Drying (of fish)
J 28(7): 1061 (practical apparatus for fillets & steaks)

Dubé, James Gilles
T 249 (methodology for identification of marine oils in hydrogenated edible oil products)

Duck, black (*Anas rubripes*)
T 272 (halogenated hydrocarbons detected in eggs)

Duedall, Ivor Warren
J 28(11): 1815 (dispenser for oxygen reagents)
S 1473 (phenosafranin indicator for chlorinity titrations)

Duffy, James Regis
J 28(1): 59 (DDT in Atl. fishes & shellfishes)
S 1552 (decrease in DDT residues in young salmon)

Dugesia tigrina (*see* Turbellaria)

Dulse (*Rhodymenia palmata*)
S 1457 (desmosterol & other sterols content)

Dyer, William John
J 28(6): 869 (octopine in postmortem muscle of sea scallop)

Dyes (*see also* Marking)
S 1539 (recommended as best means of tracing marine flushing re pollution)

Dynamics (*see also* Hydrodynamics)
A 184 (population, re exploitation of arctic ringed & harp seals)
196 (population, re fisheries biology: book review)

Dysart, Douglas Keen
J 28(8): 1181 (X-ray effects on trout embryos)

E

Eaton, Catherine Anne
J 28(4): 601 (investigation re commercial oil from sand lance)
S 1514 (lipids of Amazon R. dolphins)

Eaton, John Gates
J 28(12): 1841 (chloramine toxicity to amphipod and minnow)

Echinodermata (*see* Sea urchins; Starfish; Starfishes)

Echinoidea (*see* Sea urchins)

Echo sounding (*see* Echolocation; Sounding, echo)

Echolocation (*see also* Sounding, echo)
J 28(9): 1269 (integrated echo voltage re echo sounding for fish density)
(9): 1275 (integrated echo voltage re Puget Sound Pac. hake population estimates)
(9): 1293 (mathematical treatment of fish abundance variance estimates using fish echo integrator)
S 1515 (jaw & blubber fats composition re possible role in Amazon R. dolphin echolocation ability)
A 220 (possibilities for locating fish)

Ecology; Ecosystems (*see also* aspects of, e.g. Pollution)
J 28(1): 49 (bottom sediments, Marion L., B.C.)
(1): 73 (ecological energetics & natural history of a thermal spring dipteran herbivore)
(3): 391 (red-water ciliate *Mesodinium rubrum*)
(5): 705 (biological magnification & degradation of insecticides by freshwater invertebrates)
(7): 971 (of *Sagitta elegans* chaetognath, St. Margaret's Bay, N.S.)
(7): 1057 (effects from thermal discharge from nuclear power plants)
(10): 1545 (implications of temperature & salinity effects on Pac. herring early development)
(10): 1511 (of bacterial flora associated with surface of hatching Pac. salmon eggs, re egg mortality)
(11): 1783 (^{65}Zn vs. Zn distribution in an experimental marine ecosystem)
(12): 1877 (DDT accumulation & persistence in a lotic)
T 252 (herring larvae & macrozooplankton biomass off S N.S. coast)
262 (effects from thermal discharge from steam-electric power plants)
S 1532, 1533 (autecology re invertebrates in high mountain North Boulder Creek, Colorado)
1547 (brown trout interactions with brook trout in a Nfld. stream)
1587 (paleoecology & biostratigraphy, Santa Barbara Is., Calif.)
1589 (habitat temperature re body temperature of fishes: review)
A 189 (freshwater fish productivity re ecosystem)
230 (re human food from a northern environment)
232 (radioactivity in the marine environment: extensive summary of book)
233 (re pollution problems)

Economics (*see also* Fisheries; Management)
B 175 (economic study of Maritime Provinces oyster fishery)

Ecosystems (*see* Ecology)

Edmunds, Philip Howell
J 28(7): 1053 (tetrazolium oxidase in N Atl. tuna)

EDTA (Ethylenediaminetetraacetic acid) (*see* Chelating agents)

Eel, American (*Anguilla rostrata*)
J 28(7): 1507 (effect of warm water of nuclear power plant discharge canal)
(9): 1285 (methylmercury in N.B.)
T 261 (bibliography for Gulf of St. Lawrence)
S 1526 (physiological evidence for pituitary-adrenocortical feedback mechanism in)

Eel, deepsea spiny (*Macdonaldia challengeri*)
J 28(9): 1349 (fifth known specimen extends range to Oregon coast)

Eel, spiny (*Notacanthus nasus*) (largescale tapirfish)
T 261 (bibliography for Gulf of St. Lawrence)

Eelblenny, slender (*Lumpenus fabricii*)
T 261 (bibliography for Gulf of St. Lawrence)

Eelblenny, stout (*Lumpenus medius*)
T 261 (bibliography for Gulf of St. Lawrence)

Eelgrass (*Zostera marina*)
A 109(F) (control on oyster beds)

Eelpout, arctic (*Lycodes reticulatus*)
T 261 (bibliography for Gulf of St. Lawrence)

Eelpout, blackbelly (*Lycodopsis pacifica*)
T 221 (taken in B.C. groundfish surveys)
257 (taken in B.C. trawl fishery, 1970)

Eelpout, Laval's (*see* Eelpout, Newfoundland)

Eelpout, Newfoundland (*Lycodes lavalaei*) (Laval's eelpout)
T 261 (bibliography for Gulf of St. Lawrence)

Eelpout, pale (*Lycodes pallidus*)
T 261 (bibliography for Gulf of St. Lawrence)

Eelpout, polar (*Lycodes turneri*)
T 261 (bibliography for Gulf of St. Lawrence)

Eelpout, Vahl's (*Lycodes vahlii*)
T 261 (bibliography for Gulf of St. Lawrence)

Eelpouts (Atlantic) (*see also* names of species)
J 28(9): 1285 (methylmercury in *Lycodes atlanticus* from N.S. Banks)
T 261 (bibliography for *L. atlanticus*, *L. esmarki* & *L. seminudus* in Gulf of St. Lawrence)

Eggs, Ova (*see also* Culture; Development; Fecundity; Hatcheries; Ovary; Spawning)
J 28(1): 59 (DDT residues in N.B. lobster)
(4): 513 (size, re age of successive generations of Skeena R. sockeye salmon)
(5): 647 (results for 3 generations from pink salmon eggs transplanted to Qualicum R., B.C.)
(5): 727 (salinity & temperature effects on petrale sole embryonic development)
(5): 745; (12): 1915 (cryo-preserved sperm for fertilizing salmonid)
(6): 883 (salinity, temperature, & dissolved oxygen effects on development, re Pac. cod geographical distribution)
(8): 1119 (low oxygen concentration effects on fathead minnow females re egg hatching)
(8): 1181 (growth & fecundity of rainbow trout after eyed eggs exposure to X-rays)
(9): 1235 (vertebral count re egg size of medaka)
(10): 1511 (details of bacterial flora associated with surface of stream-incubating pink & chum salmon, re egg mortality)
(12): 1853 (proteins classification in coho salmon)
T 231 (data, arctic char in a small arctic lake)
236 (mud dab: culture & development)
246 (bibliography of N America Pac. coast trawled fishes)
272 (halogenated hydrocarbons detected in aquatic birds)
S 1468 (re spawning behaviour of crayfish)
1521 (proteins of soluble fraction of Pac. salmon species)
1557 (temperature & photoperiod effects on crayfish egg-laying)
A 190 (ICNAF report on American plaice eggs & larvae numbers in Davis & Denmark Straits)
207 (survey of distribution & abundance, N.B. & N.S. herring)

Eglinton, Geoffrey
S 1528 (geological fate of chlorophyll)

Egtved virus (*see* Viruses)

Ehrenberg, John Edward
J 28(9): 1293 (abundance estimate variance)

Eisler, Ronald
J 28(9): 1225 (cadmium poisoning in *Fundulus*)

Ekman grab (*see* Grab)

Ekman transport (of ocean waters) (*see* Transport, mass)

Electric power plants (*see* Nuclear power plant; Thermal power plant)

Electricity; Electrical effects (*see also* Electronics)
J 28(4): 565 (Atl. salmon olfactory epithelium electrical responses)
(10): 1595 (pulses during *Velella* hydroid behaviour)

Electronics (*see also* Apparatus; Echolocation)
S 1516 (bridge & amplifier for monitoring d-c level)
1517 (unijunction transistor for giving frequency divider immunity to input jitter)

Electrophoresis; Electropherograms (*Note*: This widely used procedure is no longer indexed separately; *see* materials to which it is applied, e.g. Proteins)

Elgmork Kåre
S 1532 (distribution of invertebrates)

Ellender, Rudolph Dennis
J 28(5): 788 (analysis of ammonium-nitrogen in artificial seawater aquaria)

Ellerslie, P.E.I.
J 28(1): 59 (DDT residues in smelt & shellfishes)

Ellesmere Island, N.W.T.
S 1578 (new marine dinoflagellate species, & associated phytoplankton)

Ellis, Derek Victor
J 28(10): 1433 (relation between tube-building and feeding in Polychaeta)

Elson, Paul Frederick
S 1552 (decrease in DDT residues in young salmon)

Embassichthys bathybius (*see* Sole, deepsea)

Embryos (*see also* Development; Eggs; *also* names of adult organisms)
J 28(1): 100 (device for rapid removal of fish embryos from eggs)

Emergence (*see* Development; Eggs)

Emery, Kenneth Orris
S 1511 (European flints on N American coast)

Enchelyopus cimbrius (*see* Rockling, fourbeard)

Endocrinology (*see* Hormones; Steroids)

Energetics (*see* Bioenergetics)

Energy, radiant (*see* Irradiation; Light, reactions to; Photosynthesis; Radiation; Radioactivity; X-rays)

Englar, John Randall
S 1530 (polysaccharides of red alga)

Engraulis mordax (*see* Anchovy, northern)

Enhydra lutris (*see* Sea otter)

Enolase (*see* Enzymes)

Ensis directus (*see* Clam, razor (Atlantic))

Enterobacteriaceae (*see also* Bacteria)
J 28(10): 1511 (associated with surfaces of hatching Pac. salmon eggs)

Entosphenus tridentatus (*see* Lamprey, Pacific)

Enumeration (*see* Census; Counting)

Environment (*see also* Behaviour; Ecology; Pollution, *also* factors affecting environment)
J 28(5): 778 (wave exposure re *Laminaria* seaweed taxonomy)
(6): 883 (effects on Pac. cod eggs re geographical distribution)
(7): 1057 (effects from thermal discharge from nuclear power plants)
T 200 (possibilities of X-ray fluorescence spectrophotometry of elemental composition of organisms for assessing environmental aspects)
217 (effects from spills of petroleum oil)
262 (effects from thermal discharge from steam-electric power plants)
S 1590 (re body temperature of fishes: review)
A 183 (oceanography re resources management)
201 (of Great Lakes fishes as affecting their food for man)
230 (food for man from a northern)
232 (radioactivity in the marine: extensive summary of book)

Enzymes
J 28(1): 15 (American lobster esterase isozymes polymorphisms)
(4): 613 (channel catfish plasma esterases enzymatic properties; esterase content of other fish plasmas)
(6): 869 (octopine dehydrogenase in sea scallop muscle)
(6): 879 (lobster enolase isolation & comparison with other enolases re phylogeny)
(7): 1005 (multiple malate dehydrogenase isozymes in walleye skeletal muscle, re genetics)
(7): 1015 (lysosomal triglyceride lipase from rainbow trout lateral line tissue)
(7): 1053 (genic polymorphism of bluefin tuna blood & tissues tetrazolium oxidase)
(8): 1125 (inosine 5′-monophosphohydrolase effects in iced Atl. fishes fillets)
(9): 1325 (postmortem changes in glycogen phosphorylase activity of sucker & pike muscle)
(10): 1603 (ribonucleotide reductase in sockeye salmon immature testes)
(11): 1745 (serum esterases, lactate dehydrogenases & transferrins of large & dwarf white suckers & longnose sucker)
(11): 1817 (acid phosphatase activity in *Clostridium botulinum* cells & spores)
S 1458 (glycosyl transferase from rainbow trout liver re liver glycogen structure)
1462 (pancreatic lipase reactivity as influenced by fatty acid structure)
1471 (colorimetric assay for pancreatic lipase based on acetaldehyde liberated from vinyl oleate substrate)
1508 (purification & properties of chinook salmon testes acid deoxyribonuclease)
1523 (lingcod muscle purine & pyrimidine nucleoside phosphorylases)
1524 (lingcod muscle guanine deaminase mechanism & specificity)
1525 (trout liver pyrimidine deoxynucleoside phosphorylase & deoxyribosyltransferase)
1545 (electrophoretic analysis of esterase systems in Atl. salmon × brown trout hybrids)
1560 (deoxyribonucleic acid polymerase from immature sockeye salmon testes)

A 226 (nucleoside cyclic phosphate diesterases)
227 (nucleotide phosphomonoesterases)

Eopsetta jordani (*see* Sole, petrale)

Ephemeroptera (*see* Insects, aquatic; Mayflies)

Epifauna (*see also* Benthos)
J 28(8): 1205 (two simple durable collectors for)

Epizootic (*see* Disease)

Eptatretus stoutii (*see* Hagfish, Pacific)

Equipment (*see* Apparatus)

Erie, Lake (*see also* Great Lakes)
J 28(5): 786 (heavy-metal concentrations in dressed northern pike, rainbow smelt, & yellow perch)
(8): 1133 (adult & juvenile walleye migrations between L. Huron &)
S 1543 (Oligochaeta, Sphaeriidae & Chironomidae)

Erignathus barbatus (*see* Seal, bearded)

Erimacrus isenbeckii (*see* Crabs)

Errata (*see* Corrections)

Erythropoiesis
J 28(1): 47 (re function of hemosiderin bodies in fish spleen, liver, & kidney tissues)

Escapement (*see* Spawning)

Esox americanus vermiculatus (*see* Pickerel, grass)
lucius (*see* Pike, northern)
masquinongy (*see* Muskellunge)
niger (*see* Pickerel, chain)

Esterases (*see* Enzymes)

Esters (*see also* Acids, fatty; Enzymes; Oils and fats; Waxes)
S 1549 (tropylium ion origin in arylboronic acid glycol esters mass spectra)

Estrogens (*see* Hormones)

Estuary (*see also* names of rivers and bays)
J 28(12): 1921 (herring predation on young chinook salmon in a B.C.)
S 1539 (capacity of marine to accept pollutants; use of dyes to follow flushing action)

Etheostoma nigrum (*see* Darter, johnny)

Ethers
S 1514 (diacyl glyceryl ethers composition of Amazon R. dolphin jaw & blubber fat)
1564 (diacyl glyceryl ethers composition of sea anemone *Metridium dianthus* lipids)

Ethylenediaminetetraacetic acid (EDTA) (*see* Chelating agents)

Eualis berkeleyorum (caridean shrimp)
J 28(10): 1615 (new species, off B.C. coast; also isopod parasite)

Eubothrium crassum (*see* Cestoda; Indicator species)

Eucalia inconstans (*see* Stickleback, brook)

Eudactylinidae (*see* Copepoda)

Euglenophyta
J 28(2): 192 (of several small NW Ont. lakes)

Eulachon (*Thaleichthys pacificus*)
T 210, 221 (taken during B.C. groundfish surveys)
257 (taken in 1970 B.C. trawl fishery)

Eumesogrammus praecisus (*see* Snakeblenny, fourline)

Eumicrotremus spinosus (*see* Lumpsucker, Atlantic spiny)

Euphausiids
T 252 (biomass off southern N.S. coast)
266 (Frobisher Bay, Baffin Is., N.W.T.)
S 1485 (importance & general implications of organic matter in aquatic environments, re feed for)
1527 (*Nictiphanes norvegica* sterols)
A 211 (re feed availability to different trophic levels in marine feed chain)

Euphoria longana
S 1481 (seed oil fatty acids)

Euthynnus pelanus (*see* Tuna, skipjack)

Eutrophication (*see also* Limnology; Oceanography; Pollution; Sediments; *also* types of pollutants)
J 28(2): entire issue (re 463 lakes in FRB Experimental Lakes Area, NW Ont.)
(11): 1683 (re macroinvertebrate species diversification in L. Ontario bays)
(11): 1763 (of small NW Ont. lake upon addition of phosphate and nitrate)
(11): 1811 (tolerance of fishes to alkalinity in Nebraska lakes & ponds)
T 247 (Bedford Basin, N.S., studies)
S 1482 (Bedford Basin, N.S., studies)
A 201 (in Great Lakes re pollutants effects on fishes as food)
216 (phosphates, nitrates, & carbon re the Great Lakes (polemical))

Evelyn, Trevor Patrick Todd
J 28(4): 517 (*Vibrio anguillarum*: taxonomic status & first Canadian records; correction on J 28(8): 1219)
(10): 1629 (sablefish furunculosis)
S 1497, 1498 (metabolism of putrescine)
1503 (small particles in seawater)

Evolution (*see also* Genera; Genes; Phylogeny; Speciation; Zoogeography)
J 28(7): 987 (*Salmo* species & subspecies of western N America)
(10): 1595 (*Velella* behaviour re chondrophore)

Excretion (*see* Feces; Metabolism)

Exercise (*see* Activity; Stress)

Exoskeleton (*see* Carapace)

Exploitation (*see also* Fisheries; Management; Populations)
J 28(6): 821 (Skeena R. sockeye & pink salmon, re gillnet selectivity)
(12): 1873 (bowhead whale Canadian population recovery after previous exploitation)
A 184 (arctic ringed & harp seals)
192 (Atl. salmon by foreign fisheries)
202 (summary of A 192 above)

Exploration (*see* Surveys)

Exponentials
A 189 (table of, from e^{-3} to e^{3})

Eye (*see* Light, reactions to; Vision)

F

Fallfish (*Semotilus corporalis*)
J 28(9): 1285 (methylmercury in N.B.)

Family
J 28(10): 1407 (new polychaete: Fauveliopsidae, with key to genera)

Farley, John
A 58(F) ("swimmers' itch")

Farming, aquatic (*see* Culture)

Fatigue (*see* Stress)

Fats (*see* Acids, fatty; Glycerides; Lipids; Oils and fats)

Fatty acids (*see* Acids, fatty)

Fauna, aquatic (*see also* Benthos; Biomass; Fauna, bottom; zooplankton; *also* types of)
J 28(9): 1322 (quantitative sampler for those on aquatic plants)

Fauna, bottom (*see also* Benthos; Fauna, aquatic; Sampling; Sediments; *also* types of, e.g. Insects, aquatic)
T 225 (Bay of Fundy)
S 1543 (Georgian Bay, L. Ontario, & L. Erie aquatic insects)

Fauveliopsidae (polychaetous annelids)
J 28(10): 1407 (new family)

Feces
J 28(3): 335 (surviving sedimentary bacteria those of tubificid oligochaete worms)
(7): 1064 (vs. organs re presence of pancreatic necrosis virus in brook trout)
(9): 1327 (role of copepods, in fecal sedimentation of particulate fuel oil from marine spills)

Fecundity (*see also* Eggs; Reproduction; Spawning)
J 28(3): 456 (yellowtail flounder, from Grand Bank, Nfld.
(5): 764 (Atl. salmon from 2 Maine rivers)
(7): 1029 (of right vs. left Atl. capelin ovary)
(7): 1051 (white seaperch, Tomales Bay, Calif.)
(8): 1119 (effects of low oxygen concentration on fathead minnow)
(8): 1153 (winter flounder, Long Pond, Nfld.)
(8): 1181 (rainbow trout, after eyed-embryo exposure to X-rays)
(9): 1309 (white whale)
T 231 (arctic char in a small arctic lake)
246 (bibliography of N America Pac. coast trawled fishes)
A 190 (Greenland turbot)

Feed; Feed chain; Feeding habits; Stomach contents (*see also* Culture; Feedstuff; Grazing; Metabolism; Predation; Productivity; Rations; Starvation)
J 28(3): 335 (tubificid oligochaete worms on sediment bacteria)
(3): 343 (intake & conversion factors re presmolt coho salmon growth)
(3): 409 (satiation time, appetite & maximum feed intake of sockeye salmon)
(3): 449 (bluegill sunfish protein consumption & nitrogen excretion)
(5): 776 (*Pontoporeia affinis* amphipod as fish feed source, Cayuga L., N.Y.)
(6): 861 (level effect on sockeye salmon scale circulus formation, also on fish length & weight)
(6): 928 (of 2 cohabiting tidepool sculpin species, re difference in amount of copepods eaten)
(8): 1153 (details of Nfld. winter flounder stomach contents)
(8): 1185 (bacterial counts of commercial fish diets)
(8): 1199 (Atl. salmon on scaled lancetfish)
(9): 1259 (of sympatric vs. allopatric Dolly Varden & cutthroat trouts in 3 B.C. lakes)

(10): 1433 (re tube-building in a terebellid polychaete)
(10): 1663 (of fur seal, as clue to Pac. herring offshore distribution)
(12): 1841 (experience effects on rainbow trout)
B 177 (of E Canada shellfishes re paralytic shellfish toxin retention from *Gonyaulax tamarensis*)
T 160 (of 4 *Lepidion* morid fish species)
165(F) (*Gammarus lacustris* re rainbow trout farming)
210 (of dogfish & hake off Juan de Fuca Strait)
213 (of chinook, pink, & chum salmon, & dogfish, offshore B.C.)
231 (of arctic char in a small arctic lake)
236 (of larval mud dab during culturing)
248 (*Calanus pacificus* copepod feeding rates, etc., re marine productivity)
S 1485 (aquatic organic matter as filter-feeding copepods natural feed)
1513 (*Calanus* copepod rations, re marine productivity)
1520 (cestode from stomach as clue to feed of giant squid)
1547 (re sympatry of brook & brown trout in a Nfld. stream)
1551 (of postlarval *Macoma balthica* clam)
1559 (*Uronema* ciliate ingestion of bacteria)
1575 (feeding rate re body weight of Cetacea)
A 184 (harp & ringed seal)
188 (cycle in Saanich Inlet, B.C.)
193 (capelin)
211 (plankton & pink & chum salmon, re trophic levels in feed chain)
212 (energy requirements for fish when feeding: review)
232 (radioactivity re marine feed ecosystems)
233 (pollution re aquatic feed ecosystems)

Feedback (*see* Physiology)

Feeding habits (*see* Feed)

Feedstuff (animal rations) (*see also* Feed; Fishmeal; Rations)
T 216, 257 (landings for, from B.C. & U.S. Pac. coast commercial trawling, 1969, 1970)
246 (bibliography of N America Pac. coast trawled fish for)
A 231 (utilization from N.W.T. fisheries for dogs)

Fenderson, Owen Charles
J 28(4): 505 (Atl. salmon histological comparisons)

Ferguson, Robert Gilmour
J 28(8): 1133 (migrations of walleyes)

Fernando, Constantine Herbert
J 28(3): 365 (simple corer vs. Ekman grab)

Fertilization (*see* Eggs; Reproduction; Spawning; Sperm)

Fibroma (*see* Tumours)

Fields, William Gordon
J 28(10): 1595 (studies on evolution of Chondrophora)
(11): 1796 (unusual type of Pac. gonatid squid)

Figueira, Armando Jorge Gomes
B 176 (Canadian marine zooplankton)

Fillets, fish (*see also* Quality of fishery products)
J 28(3): 305 (bacterial trimethylamine production in stored chilled haddock)
(7): 1061 (practical small-scale dryer for)
(8): 1125 (inosine 5′-phosphate degradation effects on iced)
A 203 (precooked in batter)

Finlayson, B. J.
J 28(9): 1285 (methylmercury in fish)

Fins; Fin rays
J 28(4): 553 (ray counts of spring vs. autumn spawning SW Nfld. herring)
(7): 1009 (ray counts re S Gulf of St. Lawrence seasonal herring stocks discreteness)
(10): 1672 (abnormal coloration of petrale sole)
T 192 (rays counts, Greenland halibut)

Fiords (*see* Inlets)

Firmness (of flesh) (*see also* Quality of fishery products)
T 220, 242 (sockeye salmon canned after storage of fish at sea in ice & refrigerated sea water)

Fish farming (*see* Culture)

Fish flour (*see* Fish protein concentrate)

Fish ladders (*see* Fishways)

Fish meal (*see* Fishmeal; Fish protein concentrate)

Fish oils (*see* Acids, fatty; Lipids; Oils and fats)

Fish protein concentrate (fish flour; FPC)
CHN 39 (extraction & colorimetric determination of isopropanol residues in)
A 198 (research & industrial progress, N.S.)

Fisheries (*see also* Angling; Catches; Management; Stock; Yield; *also* names of commercial fishes and shellfishes; *also* names of International Fisheries Commissions)
J 28(3): 351 (relative utilization rates of Miramichi R., N.B., Atl. salmon by local angling vs. maritime commercial fisheries)
(3): 417 (Pac. ocean perch off Oregon, Washington & B.C., 1956–65)
(3): 485 (response of brook trout populations to a fishery)
(6): 821 (gillnet selectivity of pink & sockeye salmon, Skeena R., B.C.)
(7): 1009 (discreteness of populations in Gulf of St. Lawrence spring & autumn herring)

(8): 1211 (advantages & limitations of mathematical models for catch & effort)
(12): 1873 (bowhead whale Canadian population recovery after previous exploitation)
B 175 (economic study of Maritime Provinces oyster fishery)
177 (control, re paralytic shellfish toxicity in E Canada)
178 (raft culture of Pac. oyster in B.C.)
CJG 18: 1 (recent developments in Nfld. herring purse-seining)
T 216 (summary of B.C. & U.S. Pac. coast commercial trawling, 1969)
246 (bibliography of N American Pac. coast trawl fishery & groundfish)
256 (Georges Bank scallop fishery study)
259 (rock sole landings from Cape Scott Bank, B.C., 1959–69)
MSP 13(F) (summary of FRB investigations of Canadian Arctic)
S 1473 (portable refrigerated unit for holding iced fish in remote freshwater fisheries)
1540 (Atl. cod in ICNAF Subareas 2 & 3)
1541 (American plaice in ICNAF Subarea 3)
1546 (NW Atl. squids)
A 181, 182 (ICNAF summaries of 1969 Canadian catches & research)
183 (re oceanography & ocean resources management)
184 (Canadian arctic harp & ringed seals)
185 (capelin as latent resource for Nfld.)
192, 202, 205 (Atl. salmon by countries, 1961–67; also effects of foreign Atl. salmon fisheries on Canadian fishery)
193 (capelin)
194 (Nfld.)
201 (Great Lakes: changes in production 1968 vs. 1920)
207, 219 (recent commercial & research events in Canadian Atl. herring)
208 (Bay of Fundy herring & N.B. "sardine" herring)
218 (research, very general synopsis)
225 (resume of S 1473 above)
231 (summary of FRB investigations of Canadian Arctic)

Fisheries, foreign (*see also* names of countries)
T 246 (bibliography of trawling, off N America Pac. coast)
A 192, 202, 205 (Atl. salmon, & effects on Canadian fishery)
193 (Greenland, Iceland, Norway, USSR, for capelin)
194 (off Labrador)

Fisheries Research Board of Canada (*see also* Publications and reports, Fisheries Research Board of Canada)
J 28(2): entire issue (Board's Experimental Lakes Area studies of numerous small NW Ont. lakes)
AR 1970 (Annual Report: Board purpose; research highlights; management activities; Board members; Executive Committee members; officers; establishments & their directors; Board Act (in English & French))
R 1969/1970 (Biennial review: organization; review of investigations by establishments, with lists of professional staffs; Board members; list of 1967 & 1968 Board publications & reports)
MSP 13(F) (history & nature of Canadian arctic investigations through its Arctic Biological Station)
A 231 (see MSP 13(F) above)

Fishery, sport (*see* Angling, *also* names of species, e.g., Salmon; Trout)

Fishery products; Fishery by-products (*see also* Freshwater fish products; *also* types of processing and products; *also* names of organisms; *also* Quality of fishery products)
A 215 (fishery by-products technology: book review)
203 (lessening pollution by wastewaters from)

Fishes, freshwater (*see also* Angling; Fisheries; Freshwater fish products; *also* names of species *and* bodies of fresh water)
J 28(1): 65 (L. Superior lake trout before 1950, re later lamprey invasion)
(2): enitre issue (FRB program & results in its NW Ont. Experimental Lakes Area)
(3): 452 (brook trout world distribution)
(3): 458 (brook trout populations response to a fishery)
(5): 663 (rainbow trout world distribution)
(5): 783 (effect of washing on keeping quality)
(5): 786 (heavy-metal contamination of Canadian)
(7): 1061 (practical small-scale commercial fillet & steak dryer)
(11): 1811 (alkali tolerance of 14 species in Nebraska waters)
MSP 13(F) (summary of actual & potential Canadian Arctic fisheries)
S 1473 (portable refrigerated unit for holding iced fish in remote fishing areas)
A 186 (infectious diseases of USSR, immunity & control: book review)
189 (assessment methods for production) review)
197 (metabolism & biological production:
200, 201 (mercury contamination in various species by localities)

201 (environmental effects on Great Lakes, as affecting their fishes use as human food)
225 (resume of S 1473 above)

Fishes, lists of
T 199 (taken by otter trawl, longline, & night-light during FRB *A. T. Cameron* otter-trawl survey off U.S. Atl. coast from Delaware to Florida, Feb. 1969: over 100 species; not individually indexed)
246 (bibliography of N America Pac. coast marine, especially trawled fishes)
261 (bibliography for Gulf of St. Lawrence fishes)

Fishing, exploratory (*see* Surveys)

Fishing effort (*see* Catches)

Fishmeal (*see also* Crabmeal; Fish protein concentrate; Shrimpmeal)
T 216, 257 (landings for, from B.C. & U.S. Pac. coast commercial trawling, 1969, 1970)
A 203 (protein recovery from wastewater, to reduce pollution)

Fishways; Fish ladders
J 28(4): 533 (influence on *columnaris* disease incidence, Columbia R.)
(8): 1215 (changes in blood lactic acid of alewives passing through a pool & weir)

Flabelligeridae (*see* Fauveliopsidae)

Flagellates (*see also* Dinoflagellates)
T 267 (Frobisher Bay, Baffin Is., N.W.T.)
S 1589 (morphogenesis & taxonomy of fossil & contemporary Dinophyta: reclassification of *Discoasteromonas*)

Flannagan, John Fullan
T 258 (tolerance tests on aquatic animals)

Flatfishes (*see also* Groundfish; Trawling; *also* names of species)
J 28(10): 1672 (ambicoloration of a petrale sole)
T 246 (bibliography of N America Pac. coast)

Flatworms (*see* Cestoda; Trematoda; Turbellaria)

Flavobacterium (*see* Bacteria)

Flavour (*see also* Quality of fishery products)
A 203 (nature of fresh vs. undesirable, in fishery products)

Flemer, David Andrew
J 28(6): 911 (C:N relations in Chesapeake Bay)

Fleming, Allister Melville
A 194 (Nfld. fisheries)

Flesh (*see also* Fillets; Muscle; Protein; Quality of fishery products)
J 28(4): 509 (colour of brook trout more attractive after feeding shrimp waste)
T 220, 242 (texture of canned sockeye salmon after storing fish at sea in ice or refrigerated sea water)
203 (colour enhancement, flavour, texture, etc. re fish processing)

Fletcher, Garth Leonardo
J 28(5): 793 (accumulation of phosphorus by marine invertebrates & seaweed)
T 255 (phosphorus toxicities to seawater-maintained fish)

Flints
S 1511 (origin of European on Canadian & U.S. Atl. coast)

Flocculating agents
S 1531 (polyethylenimine interaction with casein, re pollution)

Flora, aquatic (*see also* Algae; Benthos; Biomass; Eelgrass; Productivity, primary; Seaweeds; *also* names and types of)
J 28(2): 144, 215 (FRB Experimental Lakes Area, NW Ont.)
(5): 769 (assay method for ^{14}C-labelled benthos)
(9): 1322 (quantitative sampler for macrofauna on)
(12): 1877 (DDT accumulation & persistence in)
S 1475 (confusion between C_{18} & C_{20} fatty acids in seed lipids analyses)
1553 (mining effluent effects on submerged & riverside vascular plants, NW Miramichi R., N.B.)

Flora, terrestrial
J 28(4): 144 (forest cover of FRB Experimental Lakes Area, NW Ontario)
S 1475, 1481 (fatty acids of seed oils of *Symphytum officinale* & *Euphoria longana*)
1553 (mining effluent effects on vascular plants along banks of NW Miramichi R., N.B.)

Flounder, arrowtooth (*Atheresthes stomias*) (Pacific turbot)
T 210, 221, 269 (catches during B.C. groundfish surveys)
246 (bibliography)
257 (taken in 1970 B.C. trawl fishery)

Flounder, smooth (*Liopsetta putnami*)
T 261 (bibliography for Gulf of St. Lawrence)

Flounder, starry (*Platichthys stellatus*)
J 28(9): 1241 (comparison of skin tumors in 3 flatfish species)
T 216, 257 (taken in 1969 & 1970 B.C. & U.S. Pac. coast commercial trawling)
246 (bibliography)

Flounder, winter (*Pseudopleuronectes americanus*)
J 28(1): 59 (DDT residues in N.B.)
(7): 935 (regular component of Passamaquoddy Bay fish communities, N.B., & length frequencies)
(8): 1125 (purines changes in iced fillets)
(8): 1153 (distribution, movements, age, growth, & feed details, Long Pond, Nfld.)
(9): 1285 (methylmercury in Bay of Fundy & N.S. banks)
(11): 1727 (surges into intertidal zones)
(12): 1907 (factors affecting respiration rates)
T 225 (associated with Bay of Fundy scallop beds)
260 (standing crop, availability, lengths, weights) etc. from Scotian Shelf surveys, 1958–68,
261 (bibliography for Gulf of St. Lawrence)
S 1569 (determination of residual fuel oil contamination in skin, flesh, & gut)
A 200 (mercury contamination)

Flounder, witch (*Glyptocephalus cynoglossus*) (gray sole)
J 28(7): 935 (occasional component of Passamaquoddy Bay fish communities, N.B.)
(9): 1285 (methylmercury in Bay of Fundy & N.S. banks)
T 260 (standing crop, availability, lengths, weights, etc. from Scotian Shelf surveys, 1958–68)
261 (bibliography for Gulf of St. Lawrence)
A 181, 182 (ICNAF 1969 Canadian research summaries)
194 (Nfld. fishery)

Flounder, yellowtail (*Limanda ferruginea*)
J 28(3): 456 (fecundity, Grand Bank, Nfld.)
(7): 935 (occasional component of Passamaquoddy Bay fish communities, N.B.)
(9): 1285 (methylmercury in, N.S. banks)
T 260 (standing crop, availability, lengths, weights, etc. from Scotian Shelf surveys, 1958–68)
261 (bibliography for Gulf of St. Lawrence)
A 181, 182 (ICNAF Canadian 1969 research summaries)
194 (Nfld. fishery)

Flounders (lefteye) (Bothidae)
T 246 (bibliography of N America Pac. coast)

Flounders (righteye) (Pleuronectidae)
T 246 (bibliography of N America Pac. coast)
A 200 (mercury contamination, B.C.)

Flour, fish (*see* Fish protein concentrate)

Flow (*see* Currents; Tides)

Fluid mechanics (*see* Hydrodynamics)

Flukes (Trematoda)
J 28(1): 31 (*Tristoma coccinium* & *T. integrum* in N Atl. swordfish, also their possible use as indicator species)
(5): 767 (*Labrifer balli*, new species, from pink seaperch)
(6): 903 (habitat segregation of *Aporocotyle macfarlani* & *Psettarium sebastodorum* in blood system of N Pac. rockfishes, also infection incidence re those fishes habitat)
(10): 1385 (various Polychaeta as intermediate hosts of)
T 160 (3 species parasitic in *Lepidion eques*)
S 1483 (morphometric variation in *Lecithophyllum botryophorum* in Atlantic argentine)
A 58(F) (Cercariae parasitic larvae causing human "swimmers' itch" dermatitis)
224 (parasitic to N American, USSR & European coregonid fishes)

Fluorescence (*see* X-rays)

Fluorine derivatives
J 28(7): 1055 (soil or mud fluoride determination by a non-fusion distillation method)
T 233 (fluoride content of bottom deposits re pollution, Long Bay, Nfld.)
255 (fluosilicic acid toxicity tests on brook trout)
S 1505 (direct potentiometric determination of fluoride in sea water)

Flushing (*see* Currents; Oceanography; Pollution; Tides)

Food (for man) (*see also* next heading)
A 201 (environmental factors affecting Great Lakes fishes as)
230 (ecosystems, pollution, etc., re sources from a northern environment)

Food; Food chain (of other than for man) (*see* Bioenergetics; Culture; Feed; Feedstuff; Production, primary; Production, secondary)

Foraminifera
S 1587 (fossil, re Pleistocene paleoecology of Santa Barbara Is., Calif.)

Ford, Peter
J 28(1): 95 (tail growth rate in *Raja binoculata*)

Forecast
J 28(6): 801, 809, 815 (mathematical, for fish growth efficiency in nature)

Formaldehyde; Formalin
J 28(12): 1899 (stresses in young rainbow trout & coho salmon upon disinfection by)

Forrester, Clifton Roger
J 28(5): 727 (salinity & temperature effects on petrale sole)
(6): 883 (environment of Pac. cod eggs)
(10): 1672 (ambicoloration in petrale sole)
T 216 (summary report B.C. trawl fishery 1969)
236 (eggs & larvae of *Limanda yokohamae*)
246 (Pac. trawl fishery & groundfish)

Fossils
J 28(2): 265 (diatoms in sediments of 16 small NW Ont. lakes as indicators of limnological history of lakes)
S 1587 (re paleoecology & biostratigraphy, Santa Barbara Is., Calif.)
1589 (Dinophyta secreting discoasters)

Foster, Nancy Marie
J 28(10): 1455 (redescription of spionid polychaete)

FPC (*see* Fish protein concentrate)

Fragala, Robert John
J 28(5): 769 (simple reliable method for assaying ^{14}C-labelled benthic microflora)

Frantsi, Chris
J 28(7): 1064 (infectious pancreatic virus in brook trout)

Fraser River, B.C. (*see* Adams River)

Fredeen, Frederick John Hartley
J 28(1): 105 (residues of DDT, DDE, & DDD in Saskatchewan R. fish)

Freeman, Harry Cleveland
S 1489 (affinities of blood proteins in fish)

Freese, Manfred
J 28(8): 1217 (accurate labelling of fish)

Freezing (*see also* Refrigeration)
T 242 (partial, of sockeye salmon at sea in salt-fortified refrigerated sea water, re quality of canned product)
A 230 (resume of T 242 above; also complete freezing of fish)

Freshness (*see also* Quality of fishery products)
J 28(6): 869 (octopine formation in stored scallop muscle as possible index for)
A 203 (chemical nature of fresh flavour in fishery products)

Freshwater fish products (*see also* Quality of fishery products; *also* names of commercial freshwater fishes)
J 28(5): 643 (bactericidal irradiation of)
(5): 783 (beneficial effects on keeping quality by washing off slime)
(5): 786 (survey of heavy-metal contamination)
(7): 1061 (practical method for drying fish)
S 1473 (portable holding unit for iced fish)
A 225 (resume of S 1473 above)

Freshwater fishes (*see* Fishes, freshwater; Freshwater fish products)

Frieleia halli (Brachiopoda)
T 268 (in B.C. faunistic surveys since 1960)

Frobisher Bay, Baffin Is., N.W.T.
T 265, 266, 267 (biological oceanographic observations, 1967–71)

Frog, leopard
T 258 (toxicity tests of trisodium nitrilotriacetate detergent on tadpoles, re pollution)

Frost, Bruce Wesley
J 28(1): 23 (*Calanus finmarchicus* & *C. glacialis* taxonomy)

Fry (*see* names of adult fish, e.g., Salmon; Trout)

Fucose (*see* Sugars)

Fucus (*see* Seaweeds)

Fuel oil (*see* Oils, petroleum; Pollution)

Fujihara, Masaaki Paul
J 28(4): 533 (fish ladders re *columnaris* fish disease)
(9): 1253 (*Chondrococcus columnaris* disease)
(11): 1739 (disease susceptibility of young trout and salmon)

Fundulus diaphanus (*see* Killifish, banded)
heteroclitus (*see* Mummichog)
majalis (*see* Killifish, striped)

Fundy, Bay of (*see also* Oceanography, Atlantic Coast)
J 28(9): 1285 (methylmercury in fishes)
B 177 (paralytic shellfish toxicity in)
T 225 (records of associated fauna in sea scallop dredging surveys)
S 1495 (immature herring populations)

Fungi
T 245 (possible cause of mountain whitefish & rainbow trout large mortalities in Kootenay L., B.C.)

Furunculosis
J 28(10): 1629 (first spontaneous occurrence in a marine fish)

G

Gadidae (*see also* Burbot; Cods; Hake; Pollock; Tomcod)
T 246 (bibliography of Pac. N America coast)

Gadus macrocephalus (*see* Cod, Pacific)
morhua (*see* Cod, Atlantic)

Gaffkemia disease
CHN 40 (red crab resistance to)
41, 42 (nature & control in lobsters)
A 180 (causative bacterium & pathology in lobster)

Gaffkya homari (*see* Gaffkemia)

Gallop, Reginald Ambrose
J 28(5): 643 (gamma irradiation of whitefish *Salmonella*)

Gammarus (*see* Amphipoda)

Gantzer, Keith Alston
T 211 (Ocean Station P oceanographic observations)

Gar, longnose (*Lepisosteus osseus*)
T 261 (bibliography for Gulf of St. Lawrence)

Gardner, Linda Joanne
J 28(10): 1603 (ribonucleotide reductase in salmon testes)
S 1560 (deoxyribonucleic acid polymerase from salmon testes)

Garside, Edward Thomas
J 28(4): 527 (ribbed mussel upper lethal temperatures)

Gasterosteidae (*see* Sticklebacks)

Gasterosteus aculeatus (*see* Stickleback, threespine)
aculeatus complex (*see* Stickleback, threespine)
wheatlandi (*see* Stickleback, blackspotted)

Gastropoda (*see also* Snail; *also* subclassifications and names of certain species)
T 225 (associated with Bay of Fundy scallop beds)
266 (Frobisher Bay, Baffin Is., N.W.T.)
285 (toxicity tests of trisodium nitrilotriacetate detergent on, re pollution)

Gauley, Veronica Ann
J 28(11): 1796 (unusual type of Pac. gonatid squid)

Gear, fishing (*see also* Gillnets; Trap; Trawling)
T 246 (bibliography of trawling, N America Pac. coast)
270 (Canadian Atl. salmon catches by various types of)

Gee, John Henry
J 28(6): 919 (temperature effects on pre-spawning Man. sticklebacks)

Geiger, Shirley Evelyn
T 220, 242 (storage of Pac. salmon at sea)

Genera (*see also* Taxonomy)
J 28(3): 323 (*Lepeophtheirus* vs. *Dentigryps* parasitic copepods)
(3): 391 (*Mesodinium* vs. *Cyclotrichium* ciliates)
(10): 1407 (*Berkeleyia*: new polychaetous annelid genus)
(11): 1796 (need for redefinition of gonatid squid genera)
S 1488 (*Pseudoactiniscus*: new dinoflagellate genus)
1496 (*Proclavellodes*: new parasitic copepod genus from S India)
1499 (miuuse of *Caligus* in Copepoda)
1533 (*Cressoniella*: new dipteran genus from a high Colorado mountain creek)
1588 (*Harnischia* chironomids)
1589 (*Dinoasteromonas*, new flagellate genus)

Genes; Genetics (*see also* Phylogeny; Polymorphism)
J 28(1): 15 (American lobster, re esterase isozymes polymorphisms)
(6): 879 (lobster enolase & other enolases re)
(7): 1005 (of multiple malate dehydrogenase isozymes in walleye skeletal muscle)
(7): 1053 (genic polymorphism in tetrazolium oxidase in bluefin tuna blood & tissues)
T 222 (& mariculture)
S 1545 (Atl. salmon & trouts, re hybridization)
1563 (re multiple hemoglobins of rainbow & coastal cutthroat trouts)
1571 (re multiple hemoglobins of Pac. salmons & rainbow trout)

Genetics (*see* Genes)

Geology (*see also* Glaciation)
J 28(2): 139, 277 (of FRB Experimental Lakes Area, NW Ont.)
S 1511 (origin of European flints on Canadian & U.S. Atl. coast)
1528 (chemical fate of chlorophyll in ancient sediments)
1587 (paleoecology & biostratigraphy, Santa Barbara Is., Calif.)
A 199 (investigations of Gulf of St. Lawrence sediments)
221 ("holed" concretions from Georges Bank off N.S.)

Geomorphogeny
J 28(7): 987 (re evolution of western N America *Salmo* species & subspecies)
(7): 1005 (re isoenzyme phenotypes heritability of walleye from different localities)

Geomorphology
J 28(2): 139 (of FRB Experimental Lakes Area, NW Ont.)

Geopotential anomaly (*see* Currents; Oceanography; Tides)

Georges Bank, off Nova Scotia
T 256 (scallop fishery studies)

Georgia, Strait of (*see also* Juan de Fuca Strait; Oceanography, Pacific east coast)
J 28(9): 1335 (age & growth of weathervane scallop)
T 253 (temperature & current velocity program from moored meters, with examples of records, 1968–70)
S 1503 (occurrence & formation of small particles in)
A 211 (feed chains)

Georgian Bay, Lake Huron (*see also* Huron, Lake)
S 1543 (Oligochaeta, Sphaeriidae & Chironomidae)

Geryon quinquedens (*see* Crab, deep- sea red)

Gestation (*see also* Reproduction)
J 28(9): 1309 (white whale)

Getchell, Amasa Stanley
J 28(12): 1877 (DDT in lotic ecosystem)

Gillespie, Douglas Charles
J 28(5): 783 (effects of washing on keeping quality of freshwater fish)
(11): 1807 (mobilization of mercury into fish)

Gillichthys seta (gobiid fish)
J 28(11): 1809 (new record of lymphocystis viral infection, E Pac. coast)

Gillnet and netting (*see* Nets)

Gills (*see also* Blood; Hemoglobin; Respiration)
J 28(1): 115 (rakers, re anadromous vs. freshwater-resident arctic char)
(4): 465 (raker counts of lake char re N American postglacial distribution)
(4): 553 (raker counts of spring vs. autumn spawning SW Nfld. herring)
(7): 947 (blood-pressure drop in teleost, re blood pathway effects)
(10): 1609 (effects of artificial manipulation of rainbow trout)
B 177 (paralytic shellfish toxin in E Canada clams, mussel, & whelk)
S 1550 (proprioceptors in Atl. sea raven)
1554 (re rainbow trout respiratory pumps responses to hypoxia)
1566 (new species of copepod on Kenyan marine fish)

Girth (*see* Size)

Glaciation (*see also* Geology)
J 28(2): 141 (of FRB Experimental Lakes Area, NW Ont.)
(4): 465 (lake char intraspecific variations re N American postglacial distribution)
(5): 749 (re N American origin of arctic grayling having different lateral line scale counts)
(9): 1331 (re presence of relict *Pontoporeia affinis* amphipod in L. Washington, USA)

Glazing (of frozen fish)
A 203 (progress in; beneficial effects on quality of product)

GLC (gas–liquid chromatography) (*see* Note to heading Chromatography)

Globicephala macrorhyncha (*see* Whale, southern Atlantic pilot)
melaena (*see* Whale, pilot)
scammoni (*see* Whale, Pacific pilot)

Glooschenko, Walter Arthur
J 28(5): 790 (influence of nutrient enrichment on N Pac. phytoplankton)

Glucan
S 1530, 1548 (re polysaccharide structure of red seaweed *Rhodymenia pertusa*)

Glucosamine
J 28(8): 1191 (content of Dungeness crab exoskeleton)

Glucose (*see also* Glucan; Glycogen; Saccharides)
J 28(4): 606 (content of juvenile coho salmon blood)
(5): 625, 635 (levels in brook trout blood after handling, anesthetization & surgery)

Glycerides (*see also* Acids, fatty: Esters; Lipids; Oils and fats)
J 28(4): 601 (fatty acid composition of sand lance triglycerides)
(7): 1015 (rainbow trout lysosomal triglyceride lipase action on)
S 1474 (fatty acid composition in rainbow smelts)
1514 (fatty acid composition of Amazon R. sturgeon jaw & blubber triglycerides)
1564 (*trans*-6-hexadecenoic acid & other fatty acids of sea urchin *Metridium dianthus*)
1572 (amounts & fatty acids of, in periwinkle, Atl. oyster & quahaug lipids)

Glycerol (*see* Glycerides)

Glycogen
J 28(1): 7 (seasonal changes in various food-reserve types of, in freshwater triclad flatworm)
(9): 1325 (postmortem changes in phosphorylase activity of sucker & pike muscle)
S 1458 (rainbow trout liver transferase re liver glycogen structure)

Glycol
S 1549 (tropylium ion origin in mass spectra of arylboronic acid esters of ethylene glycol)

Glycoproteins
J 28(8): 1173 (constituents levels in Pac. salmons, trouts, & bovine blood sera)

Glyptocephalus cynoglossus (*see* Flounder, witch)
zachirus (*see* Sole, rex)

Gobiosoma paradoxum (gobiid fish)
J 28(11): 1809 (new record of lymphocystis viral infection, E Pac. coast)

Godfrey, Harold
CNG 90 (U.S. hatcheries chinook & coho production)

Goldeye (*Hiodon alosoides*)
J 28(1): 105 (DDT residues in muscle of, Saskatchewan R.)
A 200 (mercury contamination, Saskatchewan R.)

Goldfish (*Carassius auratus*)
J 28(7): 957 (vulnerability to northern pike predation)

Goldsack, Douglas Eugene
S 1522 (optical detection pressure apparatus)

Gonadectomy (*see* Hormones; Maturity; Ovary; Reproduction; Spawning; Sperm; Testes)

Gonadotropin (*see* Pituitary)

Gonads (*see also* Ovary; Testes)
B 177 (paralytic shellfish toxin in E Canada clams, mussels, & whelk)

Gonyaulax (dinoflagellates)
B 177 (*G. tamarensis* re paralytic shellfish toxicity in E Canada; similarity to *G. catanella* on Pac. coast)

Goosefish (*Lophius americanus*) (angler; monkfish)
J 28(7): 935 (occasional component of Passamaquoddy Bay fish communities, N.B.)
(9): 1285 (methylmercury in, N.S. banks)
T 260 (standing crop, availability, lengths, weights, etc. from Scotian Shelf surveys, 1958–68)
261 (bibliography for Gulf of St. Lawrence)

Gordon, Donald Collingwood, Jr.
J 28(12): 1912 (fuel oil concentration in Chedabucto Bay)

Gots, Barra Louise
J 28(3): 452 (world distribution of brook trout, further observations)

Gourami, blue (*Trichogaster trichopterus*)
J 28(1): 47 (spleen, liver, & kidney hemosiderin bodies re erythropoiesis)

Grab
J 28(3): 365 (Ekman grab vs. simple corer for sampling shallow-water benthos)

Graham, Brian William
J 28(2): 277 (surface sediment chemistry of FRB Experimental Lakes, NW Ont.)

Grainger, Edward Henry
B 176 (Canadian marine zooplankton)
T 265 (physical, nutrient, & production observations in Frobisher Bay)
266 (zooplankton data in Frobisher Bay)

Grand River, Ont.
J 28(1): 35, 45 (effects on benthos & fishes upstream & downstream of impoundment dam)

Gravel (*see* Spawning)

Gray, James Rutherford
J 28(4): 559 (freshwater zooplankton calorific values)

Grayling, arctic (*Thymallus arcticus*)
J 28(5): 749 (geographic variation in lateral line scale counts re N American origin)

Grazing (*see also* Copepoda; Feed; Production, secondary)
J 28(11): 1733 (production potential of seaweed–lobster community, St. Margaret's Bay, N.S.)
T 248 (aspects of nocturnal vs. continuous, by planktonic herbivores re production studies)
S 1513 (zooplankton rations re phytoplankton mortality, re marine productivity estimation)
1586 (of phytoplankton during 25-hour chlorophyll budget study)
A 211 (by zooplankton, re feed availability to different trophic levels in marine feed chain)

Great Lakes (*see also* names of individual Great Lakes)
J 28(4): 616 (size of giant brook lampreys re average adult size)
S 1490 (history of lamprey invasion & combating it)
1543 (aquatic insects of Georgian Bay, L. Ontario, & L. Erie)
A 200, 201 (mercury contamination of various food fishes)
201 (fishes' environmental factors as affecting their food for man)
216 (phosphates re eutrophication (polemical))

Great Lakes Fishery Commission
S 1484 (molecular structure re lampricide activity of halogenated mononitrophenols)

Green, James Harvey
J 28(3): 446 (electronic processing of acoustical data for fishery research)

Green, John Marshall
J 28(3): 383 (the tidepool sculpin (*Oligocottus maculosus*)

Green, Roger Harrison
J 28(5): 776 (lipid and caloric contents of Cayuga L. relict amphipod)

Greenfield, Leonard Julian
S 1519 (protein, amino acids, and ammonia determination in marine sediments)

Greenland
A 191 (survey of American plaice eggs & larvae numbers)
192 (marine salmon fishery effect on Canadian fishery)
193 (capelin fishery)
202, 205 (summaries of A 192 above)
228 (Jakob Danielson, a Greenlandic painter: book review)

Greenling, kelp (*Hexagrammos decagrammus*)
T 257 (taken in 1970 B.C. trawl fishery)

Greenling, masked (*Hexagrammos octogrammus*)
J 28(6): 927 (range extension SE from Alaskan to B.C. coast; meristic data)

Greenling, whitespotted (*Hexagrammos stelleri*)
T 257 (taken in 1970 B.C. trawl fishery)

Greenlings (Hexagrammidae)
T 246 (bibliography of N America Pac. coast)

Grenadier (*Macrourus* (*Coryphaenoides*) *rupestris*)
J 28(9): 1285 (methylmercury in, N.S. banks)

Grenadier, roughhead (*Macrourus berglas*)
T 261 (bibliography for Gulf of St. Lawrence)

Grenadiers (Atlantic)
T 260 (availability, standing crop, lengths, weights, etc. of the common grenadier, from Scotian Shelf surveys, 1958–68)

Grey (*see* Gray)

Grilse (*see* name of adult salmons or trouts)

Groundfish (*see also* Catches; Fisheries; Trawling; *also* names of commerical groundfishes)
T 210, 221, 269 (observations during surveys off B.C. & Washington coasts, 1970–71)
246 (bibliography of trawl fishery & groundfish, N American Pac. coast)
260 (abundance, availability, yields, etc., 1958–68 Scotian Shelf surveys)
A 194, 195 (Nfld. & Labrador fisheries)

Growth (*see also* Age; Development; Size; Weight)
J 28(1): 65 (L. Superior lake trout before lamprey invasion)
(1): 73 (tail of big skate embryo, re respiration)
(3): 343 (salinity effects on pre-smolt coho salmon)
(4): 537 (jaw tagging effects on landlocked Atl. salmon)
(5): 711 (2 amphipod species, Marion L., B.C., re secondary production)
(5): 755 (harbour seal pups, Sable Is., N.S.)
(6): 801, 809, 815 (fish growth efficiency analysis; prediction; mathematical models)
(6): 924 (temperature requirements for larval lake cisco)
(7): 971 (*Sagitta elegans* arrow worm, re temperature, St. Margaret's Bay, N.S.)
(7): 1009 (rate, re discreteness of S Gulf of St. Lawrence seasonal herring stocks)
(8): 1071 (sodium chloride effects on *Clostridium botulinum*)
(8): 1153 (winter flounder, Long Pond, Nfld.)
(8): 1181 (rainbow trout, after eyed-embryo exposure to X-rays)
(9): 1309 (white whale, Cumberland Sound, Baffin Is., N.W.T.)
(9): 1335 (& age of weathervane scallop, Washington coast)
(10): 1621 (northern rockfish)
(10): 1635 (responses of young sockeye salmon to different diets & nutrition levels)
T 231 (arctic char in a small arctic lake)
232 (razor clam, Queen Charlotte Is. & W coast Vancouver Is., B.C.)
243 (tank-cultured sablefish)
250 (computer programming of data)
S 1494 (behaviour of growth & mortality estimates based on age–length keys)
1559 (*Uronema* marine ciliate in culture)
1590 : 545 (temperatures for optimum growth of various fishes: review)
A 179(F) (redfish)
190 (Greenland turbot)
193 (capelin)
214 (hormones for delaying sexual maturation in fish farming, to allow greater growth)

Grubby (*Myoxocephalus aenaeus*)
J 28(7): 935 (occasional component of Passamaquoddy Bay fish communities, N.B.)
T 261 (bibliography for Gulf of St. Lawrence)

Gruchy, Charles George
J 28(9): 1347 (record of bluespotted poacher in B.C.)

Guanine (*see* Purines)

Guillemot, common (*Uria aalgae*)
T 272 (halogenated hydrocarbons detected in eggs)

Gull, herring (*Larus argentatus*)
T 272 (halogenated hydrocarbons detected in eggs)

Gunderson, Donald Raymond
J 28(3): 417 (Pac. ocean perch reproductive patterns)

Gunnel, rock (*Pholis gunnellus*)
J 28(7): 935 (occasional component of Passamaquoddy Bay fish communities, N.B.)
T 225 (associated with Bay of Fundy scallop beds)
261 (bibliography for Gulf of St. Lawrence)

Guppy (*Poecilia reticulata*)
S 1535 (chinook salmon gonadotropin effect on sexual behaviour of hypophysectomized & gonadectomized female)

Gymnelis viridis (*see* Doctor, fish)

Gymnocanthus tricuspis (*see* Sculpin, arctic staghorn)

H

Habitat (*see also* Behaviour; Environment)
J 28(6): 903 (of 2 blood fluke species in N Pac. rockfishes re habitat of those fishes)

Haddock (*Melanogrammus aeglefinus*)
J 28(1): 1 (dimethylamine production in dark muscle during frozen storage)
(3): 305 (bacteria producing trimethylamine from trimethylamine oxide in chilled fillets)
(7): 935 (regular component of Passamaquoddy Bay fish communities, N.B., & length frequencies)
(8): 1125 (purines changes in iced fillets)
(9): 1285 (methylmercury in, N.S. banks)
T 225 (associated with Bay of Fundy scallop beds)
260 (standing crop, availability, lengths, weights, etc. from Scotian Shelf surveys, 1958–68)
T 261 (bibliography for Gulf of St. Lawrence)
S 1460 (bacterial spoilage of irradiated, re pre-irradiation quality)
1492 (movements of tagged, off Digby, N.S.)
1507 (standard, extreme total, & fork length conversion factors)
A 181, 182 (ICNAF 1969 Canadian research summaries)
194 (Nfld. fishery)
206 (ICNAF study on recruitment & stock abundance forecast for 1970–72)

Haegele, Carl Walter
T 210 (*G. B. Reed* groundfish cruise 70–2)

Haemobaphes (*see* Copepoda)

Hagfish, Atlantic (*Myxine glutinosa*) (northern hagfish)
J 28(7): 935 (occasional component of Passamaquoddy Bay fish communities, N.B.)
T 225 (associated with Bay of Fundy scallop beds)
261 (bibliography for Gulf of St. Lawrence)

Hagfish, northern (*see* Hagfish, Atlantic)

Hagfish, Pacific (*Eptatretus* (*Polistotrema*) *stouti*)
T 221 (taken in B.C. groundfish surveys)

Hair
J 28(6): 843 (zinc level in rat, when fed P.E.I. oysters)

Hake, longfin (*Phycis* (*Urophycis*) *chesteri*)
T 261 (bibliography for Gulf of St. Lawrence)

Hake, Pacific (*Merluccius productus*)
J 28(9): 1269 (integrated echo voltage re echo sounding for)
(9): 1275 (integrated echo voltage for estimating populations in Puget Sound, Wash.)
T 210, 221, 269 (catches during B.C. groundfish surveys, *also* observations of USSR hake trawling)
210 (size & sex composition; feed)
246 (bibliography)
257 (taken in 1970 B.C. trawl fishery)

Hake, red (*Urophycis chuss*) (squirrel hake)
J 28(9): 1285 (methylmercury in, N.S. banks)
T 225 (associated with Bay of Fundy scallop beds)
261 (bibliography for Gulf of St. Lawrence)

Hake, silver (*Merluccius bilinearis*)
J 28(1): 1 (trimethylamine production in dark muscle during frozen storage)
(7): 935 (summer periodic component of Passamaquoddy Bay fish communities, N.B., & length frequencies)
(9): 1285 (methylmercury in, N.S. banks)
T 260 (standing crop, availability, lengths, weights, etc. from Scotian Shelf surveys, 1958–68)
261 (bibliography for Gulf of St. Lawrence)
A 182 (ICNAF Canadian 1969 research summary)

Hake, spotted (*Urophycis regius*)
T 261 (bibliography for Gulf of St. Lawrence)

Hake, squirrel (*see* Hake, red)

Hake, white (*Urophycis tenuis*)
J 28(1): 59 (DDT residues in N.B.)
(7): 935 (summer periodic component of Passamaquoddy Bay fish communities, N.B., & length frequencies)
(9): 1285 (methylmercury in Bay of Fundy & N.S. banks)
T 260 (standing crop, availability, lengths, weights, etc. from Scotian Shelf surveys, 1958–68)

261 (bibliography for Gulf of St. Lawrence)
272 (halogenated hydrocarbon residues detected in)

Halibut, Atlantic (*Hippoglossus hippoglossus*)
J 28(1): 1 (amine production in frozen stored muscle)
(7): 935 (occasional component of Passamaquoddy fish communities, N.B.)
(8): 1125 (purines changes in iced fillets)
(9): 1285 (methylmercury in, N.S. banks)
T 260 (standing crop, availability, lengths, weights, etc. from Scotian Shelf surveys, 1958–68)
261 (bibliography for Gulf of St. Lawrence)

Halibut, California (*Paralichthys californicus*)
T 246 (bibliography)

Halibut, Greenland (*Reinhardtius hippoglossoides*) (Greenland turbot)
J 28(7): 935 (regular component of Passamaquoddy Bay fish communities, N.B., & length frequencies)
(9): 1285 (methylmercury in, N.S. banks)
T 192 (vertebral & other meristic characteristics)
246 (bibliography, W Arctic coast)
261 (bibliography, Gulf of St. Lawrence)
A 181, 182 (ICNAF Canadian 1969 research summaries)
190 (general biology)
194 (Nfld. fishery)

Halibut, Pacific (*Hippoglossus stenolepis*)
T 221, 269 (catches during B.C. groundfish surveys)
257 (taken in 1970 B.C. trawl fishery)

Halifax Harbour, N.S.
T 219 (sea level variations analysis)

Halliday, Ralph Gilmore
A 206 (1970–72 haddock recruitment & abundance)

Hamilton, Andrew Lloyd
J 28(2): 257 (zoobenthos of 15 FRB Experimental Lakes, NW Ont.)
S 1536 (deformed larvae in Canadian lakes)
1543 (components of bottom fauna, Great Lakes)

Hamilton, Robert Duncan
S 1519 (protein, amino acids, & ammonia determination in marine sediments)
1559 (cultural characteristics of pelagic marine hymenostome ciliate)

Hammerhead, scalloped (*Sphyrna lewini*) (hammerhead shark)
A 182 (ICNAF Canadian 1969 research summary)

Handling
J 28(5): 625 (physiological effects of, on brook trout)
(12): 1823 (effects on striped bass oxygen requirements)
T 242 (harmful effect of mishandling sockeye salmon during catching & storage at sea for processing)
A 203 (fish on vessels and in processing plants)

Hansen, Judith Anne
T 209 (filing bibliographic references)

Hardness of natural waters (*see also* Calcium derivatives; Carbonate)
J 28(1): 73 (thermal springs, Mt. Rainier National Park, USA)
(2): 171 (many small NW Ont. lakes)
T 202 (re diatoms & heavy-metal pollutants, NW Miramichi R., N.B.)

Harling, Wayne Robert
T 221 (*G. B. Reed* groundfish cruise 70–3)

Harman, Paul Douglas
J 28(1): 113 (tricaine methanesulfonate in fish muscle)

Harnischia (Chironomidae)
S 1588 (nomenclature & phylogeny; synonymy)

Hart, Josephine Frances Lavinia
J 28(10): 1527 (reptant decapod Crustacea)

Hartman, Olga
J 28(10): 1407 (compendium of abyssal polychaetous annelids)

Harvesting (*see also* Apparatus; Catches; Culture; Fisheries; Nets; Traps; Trawling; etc.)
B 177 (regulations re paralytic shellfish toxicity in E Canada)
178 (Pac. oyster cultured on rafts in B.C.)

Harvey, Harold Henry
J 28(12): 1883 (Manitoulin lakes limnology)

Hassan, El Sayed Mohamed
T 219 (physical oceanography of St. Margaret's Bay)

Hatcheries (*see also* Culture; Eggs)
J 28(4): 587 (factors influencing activity scope & active & standard metabolism in wild vs. hatchery rainbow trout)
(8): 1185 (bacterial counts of commercial fish diets)
(9): 1350 (infectious pancreatic necrosis virus found in brook trout in 2 Ont.)
CNG 90 (coho & chinook salmon production by U.S.)

Hatching (*see* Culture; Development; Eggs; Hatcheries)

Hauser, Brian William
J 28(2): 129 (initial survey of FRB Experimental lakes, NW Ont.)

Haynes, Evan Baxter
J 28(9): 1335 (age & growth of giant Pac. sea scallop)

Healey, David Andrew
T 211 (Ocean Station P oceanographic observations)

Heart (*see also* Blood; Hemoglobin; Respiration)
J 28(1): 15 (tissue esterase isozymes polymorphisms in American lobster)
(4): 491 (cardiac responses to anoxia in sea raven)
(5): 781 (improved vascular catheterization procedure for teleost fish aorta)
(11): 1793 (*see* T 229 below)
T 229 (feeding rats raw or partially hydrogenated Atl. herring oil re fat deposition in)
S 1575 (weight re body weight & feeding rate of Cetacea)

Hedriodiscus truquii (*see* Diptera)

Helminths (*see* classifications of)

"Hemagglutinogens"
J 28(8): 1208 (comparative heteroagglutination & agglutination inhibition of mummichog & striped killifish erythrocytes)

Hematocrit (*see* Blood; Hemoglobin)

Hemibaphes intermedius (*see* Copepoda)

Hemigrapsus oregonensis (*see* Crab, green shore)

Hemithiris psittacea (Brachiopoda)
T 268 (in B.C. faunistic surveys since 1960)

Hemitripterus americanus (*see* Raven, sea)

Hemoglobin (*see also* Blood; Respiration)
J 28(4): 606 (content of juvenile coho salmon)
(10): 1621 (electropherograms re northern rockfish taxonomy)
(11): 1745 (of dwarf & large white suckers & longnose sucker)
S 1563 (subunit allelic polypeptides & molecular basis of rainbow & coastal cutthroat trouts multiple hemoglobins)
1571 (polypeptides re molecular basis for multiplicity of Pac. salmons & rainbow trout hemoglobins)

Hemolymph (*see also* Blood)
J 28(8): 1191 (amino acids of Dungeness crab)

Hemosiderin bodies
J 28(1): 47 (as storage sources of iron in fish spleen, liver, & kidney tissues)

Hennick, Daniel
J 28(4): 608 (hermaphroditic specimen of weathervane scallop)

Hepatopancreas (*see also* Pancreas)
J 28(5): 793 (selective accumulation of yellow phosphorus from sea water by lobsters)
(8): 1191 (fatty & amino acids of Dungeness crab)

Hepatoxylon trichiuri (*see* Cestoda)

Herbicides
S 1536 (possible cause of deformed chironomids larvae in L. Erie & Okanagan R. lakes, B.C.)
A 109(F) (2,4-D ester for eelgrass control on oyster beds)

Heredity (*see also* Evolution; Genes)
J 28(7): 1005 (re phenotypes of malate dehydrogenase isoenzymes in skeletal muscle of walleye from different locations)

Hermaphroditism
J 28(4): 608 (of an Alaskan weathervane scallop)

Herring, Atlantic (*Clupea harengus harengus*)
J 28(4): 553 (meristic differences between SW Nfld. spring & autumn spawning)
(7): 935 (regular component of Passamaquoddy Bay fish communities, N.B., & length frequencies)
(7): 1009 (discreteness of Gulf of St. Lawrence populations in spring & autumn fisheries)
(9): 1285 (methylmercury in, N.S. banks)
(11): 1793 (*see* T 229 below)
CJG 18: 1 (recent developments in Nfld. fishery); 20 (tagging results in SW Nfld. coastal waters); 25 (investigations in NE Nfld. & Labrador)
T 217 (petroleum oil characterization re source of pollution toxicity to)
229 (rat tests to see if feeding raw or partially hydrogenated herring oil causes heart or liver fat deposition)
252 (larvae ecology & distribution along southern N.S. coast)
255 (yellow phosphorus toxicity tests)
261 (bibliography for Gulf of St. Lawrence)
272 (halogenated hydrocarbon residues detected in)
S 1464 (critique on otolith use for aging Gulf of St. Lawrence)
1495 (Bay of Fundy populations of immature)
1584 (mortality from pollution of N Sydney

Harbour, N.S., by coke-oven intermediate oil)
1591 (pristane & other hydrocarbons in Canadian commercial oil)
A 181, 182 (ICNAF Canadian 1969 research summaries)
194 (Nfld. fishery)
200 (mercury contamination)
207, 219 (recent commercial & research events in Canadian fishery)
208 (Bay of Fundy vertebral numbers; origin of N.B. "sardine" herring)
219 (*Anasakis* roundworm infection incidence variation)

Herring, blueback (*Alosa aestivalis*)
J 28(7): 1057 (effect of warm water of nuclear power plant discharge canal)

Herring, lake (*see* Cisco, lake)

Herring, Pacific (*Clupea harengus pallasi*)
J 28(9): 1269 (integrated echo voltage re echo sounding for)
(10): 1545 (combined temperature & salinity effects on eggs & early development)
(10): 1663 (offshore distribution, on basis of fur seal stomach contents records)
(12): 1921 (predation on young chinook salmon in B.C. estuary)
T 210, 221 (catches during B.C. trawl surveys)
213 (B.C. offshore surveys, 1969)
257 (taken during 1970 B.C. trawl fishery)
A 200 (mercury contamination, B.C.)

Herrington, Harry Biggar
S 1543 (components of bottom fauna Great Lakes)

Herudinea (*see* Leeches)

Hesperophylax oreades (*see* Caddisflies)

Hewitt, Gordon Christopher
J 28(3): 323 (species of *Lepeophtheirus* from sunfish)
(8): 1143 (locomotion in Caligidae)

Hexagrammidae (greenlings)
T 246 (bibliography of N America Pac. coast)

Hexagrammos decagrammus (*see* Greenling, kelp)
octogrammus (*see* Greenling, masked)
stelleri (*see* Greenling, whitespotted)

Hexosamine (*see* Sugars)

Hexose (*see* Sugars)

Hexuronic acid
J 28(8): 1173 (levels in salmon, trout, & bovine blood sera)

Hiltz, Doris Fraser
J 28(6): 869 (octopine in postmortem muscle of sea scallop)

Hines, James Alexander
J 28(8): 1125 (inosine phosphate breakdown in fishes)

Hiodon alosoides (*see* Goldeye)

Hippoglossoides elassodon (*see* Sole, flathead)
platessoides (*see* Plaice, American)

Hippoglossus hippoglossus (*see* Halibut, Atlantic)
stenolepis (*see* Halibut, Pacific)

Hirudinoidea (*see* Leeches)

Histology (*see also* Cytology; Morphology)
J 28(1): 47 (blue gourami spleen hemosiderin bodies)
(1): 112 (cutthroat trout organs re leukemia condition)
(3): 391 (red-water ciliate *Mesodinium rubrum*)
(3): 448 (lake trout subcutaneous fibroma)
(4): 477, 485 (effects of hormones & cortisol on tissues of gonadectomized sockeye salmon)
(4): 505 (comparisons of adrenal-cortical cells of wild vs. hatchery landlocked Atl. salmon)
(6): 903 (blood fluke parasitism in copper rockfish)
(7): 947 (gill lamella of teleosts re gill blood pressure)
(8): 1198 (supernumerary copulatory organs in *Dugesia tigrina* turbellarian)
(9): 1241 (Pac. flounders skin tumours)
(10): 1677 (sea anemone nematocyst types)
(11): 1793 (heart of rat fed raw or hydrogenated Atl. herring oil)
S 1477 (Ledig cell homolog in Atl. salmon testis)
1478 (Atl. salmon interrenal tissue, re steroidogenesis)
1536 (deformed chironomids larvae)
1550 (Atl. sea raven gill proprioceptors)
1551 (postlarval *Macoma balthica* clam)
1562 (Atl. salmon mid-testis re androgens)
1574 (oral remnants of nasopalatine canals in fin whales)

History (*see also* Life history)
J 28(3): 452 (worldwide distribution of brook trout)
(5): 663 (worldwide introductions of rainbow trout)
B 175 (Maritime Provinces oyster industry)
177 (paralytic shellfish poisoning, Canadian Atl. coast)
S 1490 (lamprey invasion of Great Lakes & combating it)

Hitz, Charles Robert
J 28(9): 1335 (age & growth of giant Pac. sea scallop)

Hledin, R. V.
J 28(8): 1173 (Pac. salmon glycoprotein constituents)

Hodder, Vincent Mackay
J 28(4): 553 (Atl. herring meristic characters)

CJG 18: 1 (Nfld. herring fishery recent developments)
A 219 (Atl. herring fisheries)

Hodgkiss, Willie
J 28(10): 1511 (identification of bacterial flora in salmon streams)

Hogan, James William
J 28(4): 613 (enzymatic properties of plasma esterases, channel catfish)

Hogan, Roger Lloyd
J 28(4): 610 (concentrations of dieldrin in blood & brain of green sunfish at death)

Holding (*see also* Chilling; Ice; Refrigeration; Sea water, refrigerated; Storage)
S 1473 (portable refrigerated unit for iced fish in remote freshwater fisheries)

Holmes, John Carl
J 28(6): 903 (habitat segregation in blood flukes)

Holmgren, S. K.
J 28(2): 189 (primary production & phytoplankton of FRB Experimental Lakes, NW Ont.)
(11): 1763 (eutrophication of one of FRB Experimental Lakes, NW Ont.

Holobomolochus (cyclopoid parasitic copepods)
J 28(10): 1563 (description of *H. venustus* & *H. occultus*, new species; first B.C. record for *H. spinulus*)

Holopedium (*see* Cladocera)

Holothuroidea (*see* Sea cucumbers)

Homarus americanus (*see* Lobster, American)

Homing (*see also* Odour; Marking; Migration; Spawning; Tagging)
J 28(3): 383 (behaviour of tidepool sculpin)

Hooper, Shirley Norma
T 249 (methodology for identification of marine oils in hydrogenated edible oil products)
S 1481 (fatty acids from *Euphoria longana*)
1528 (geological fate of chlorophyll)
1564 (*trans*-6-hexadecenoic acid and alcohol in sea anemone lipids)
1572 (distribution of fatty acids in lipids of 3 species of molluscs)

Hormones (*see also* Steroids)
J 28(4): 477, 485 (histological effects on tissues of gonadectomized sockeye salmon)
(4): 505 (histology of adreno-cortical cells in Atl. salmon)
S 1488 (binding affinities of blood proteins for steroid, of 3 Atl. fishes)
1535 (chinook salmon gonadotropin effect on sexual behaviour of hypophysectomized & gonadectomized female guppies)
1562 (major, in sexually maturing Atl. salmon testicular & peripheral plasma)
1576 (Atl. sturgeon plasma corticosteroids & testosterone)
A 214 (sex, re fish farming)

Horne, David Alexander
T 255 (phosphorus toxicities to seawater-maintained fish)
S 1562 (stages of sexual development in Atl. salmon)

Horton, Howard Franklin
J 28(5): 745 (cryo-preserved sperm fertilize salmon eggs)
(12): 1915 (preservation of trout sperm)

Hoskins, Gary Edward
J 28(10): 1511 (identification of bacteria flora in salmon streams)
T 245 (B.C. wild fish mortalities)

Hotsprings (*see* Springs, thermal)

Houston, Arthur Hillier
J 28(5): 625 (handling and anesthetization effects on brook trout)
(5): 635 (brook trout variations re surgery)
(5): 781 (improvement in vascular catheterization procedure for salmonid and other teleost fishes)

Hoyle, Richard James
T 255 (phosphorus toxicities to seawater-maintained fish)
S 1471 (lipase assay based on acetaldehyde liberation from vinyl oleate)

Hubbard, Lyle Turner, Jr.
J 28(12): 1831 (distribution and abundance of Salpidae)

Hudson Bay
A 200 (mercury contamination of fishes & marine mammals)

Hughes, George Morgan
S 1554 (responses of respiratory pumps to hypoxia in rainbow trout)

Hughes, Roger Neville
S 1580 (classification of P.E.I. benthic samples)

Hungate, Frank Porter
J 28(4): 533 (fish ladders re *columnaris* fish disease)

Hunter, John Gerald
T 231 (lake potential in production of landlocked arctic char)
MSP 13(F) (studies in Canada's Arctic)
A231 (FRB studies in Canada's Arctic)

Huron, Lake (*see also* Georgian Bay; Manitoulin Island; Great Lakes)
J 28(4): 616 (giant brook lampreys size re average adult size)
(8): 1133 (adult & juvenile walleye migrations between L. Erie &)
(12): 1857 (B.C. & U.S. kokanee transplants into)

Hurst, Robert Edward
S 1522 (optical detection pressure apparatus)

Hutzinger, Otto
S 1463 (identification of polychlorinated biphenyls & DDT)

Hwang, Pei Chu
S 1471 (lipase assay based on acetaldehyde liberation from vinyl oleate)

Hyalella aztecta (*see* Amphipoda)

Hynes, Hugh Bernard Noel
J 28(1): 35 (differences in benthos caused by an impoundment)
(1): 45 (differences in fish populations caused by mainstream impoundment)

Hyas araneus (*see* Crabs, toad)

Hybopsis biguttatus (*see* Chub, hornyhead)
gracilis (*see* Chub, flathead)
micropogon (*see* Chub, river)
plumbea (*see* Chub, lake)

Hybridization
J 28(7): 987 (*Salmo* "*rosei*" considered a hybrid of golden trout × Kern R. trout)
S 1545 (electrophoretic analysis of Atl. salmon × brown trout protein & esterase systems re detecting hybrids in natural populations)
A 214 (sex hormones to accelerate sexual maturity for testing)

Hydrocarbons (*see also* Insecticides; Lipids; Oils, petroleum)
T 272 (polychlorinated biphenyls & other industrial halogenated hydrocarbons in the environment: review, assay methods, & bibliography)
S 1558, 1570 (polychlorinated biphenyls: toxicity & uptake from sea water)
1584 (in pollution from coke-oven intermediate oil as cause of fish mortality)
1591 (pristane, phytane & other alkanes in some marine & freshwater Canadian commercial fish oils)

Hydrodynamics (*see also* Currents; Hydrography; Oceanography; Transport, mass)
T 264 (fluid mechanics of netting & low-solidity screens)

Hydrogen
A 232 (^{3}H (tritium) as marine radioactive pollutant)

Hydrogen sulphide (*see* Sulphides)

Hydrogenated oils & fats
T 249 (analysis methods for detecting marine oil adulteration of all-vegetable margarine & cooking fats)

Hydrography (*see also* Oceanography)
T 199 (SW north Atl. Ocean, 1969)
A 181, 182 (ICNAF Canadian 1969 research summaries)

Hydroids
J 28(10): 1595 (*Velella* behaviour re chondrophore evolution; arguments to consider *V.* as hydroids; electrical pulses in)
T 225 (associated with Bay of Fundy scallop beds)

Hydrolagus colliei (*see* Ratfish)

Hymenoptera (*see also* Insects, aquatic)
S 1532 (*Copidosoma naevia* of a high Colorado mountain creek)

Hypocholesterolemia (*see* Sterols)

Hypophysectomy (*see* Pituitary gland)

Hypoxia (*see* Respiration)

Hypsopsetta guttulata (*see* Turbot, diamond)

I

Ice; Icing (*see also* Chilling; Refrigeration)
T 220 (effects of storing sockeye salmon in ice vs. refrigerated sea water on quality of canned product)
265 (depth & contained nutrients, Frobisher Bay, Baffin Is., N.W.T.)
S 1473 (portable refrigerated unit for holding iced fish in remote freshwater fisheries)
A 203 (fish on boats & in processing plants)
225 (resume of S 1473 above)

Icelus bicornis (*see* Sculpin, twohorn)
spatula (*see* Sculpin, spatulate)
spiniger (*see* Sculpins)

Ichthyomyzon bdellium (*see* Lamprey, Ohio)
castaneus (*see* Lamprey, chestnut)
unicuspis (*see* Lamprey, silver)

ICNAF (*see* International Commission for the Northwest Atlantic Fisheries)

Icosteus aenigmaticus (*see* Ragfish)

Ictalurus catus (*see* Catfish, white)
melas (*see* Bullhead, black)
natalis (*see* Bullhead, yellow)
nebulosus (*see* Bullhead, brown)
punctatus (*see* Catfish, channel)

Ictiobus cyprinellus (*see* Buffalo, bigmouth)

Identification (*see* Keys)

Idler, David Richard
J 28(10): 1675 (sterols of a brachiopod)
S 1457 (desmosterol content of dulse red algae sterols)
1459 (new marine sterol)
1477 (Leydig cell homolog in testis of sexually mature Atl. salmon)
1478 (identification of interrenal tissue in American Atl. sturgeon)
1479 (in-vitro steroidogenesis in yellow bodies of American Atl. sturgeon)
1489 (affinities of blood proteins in fish)
1506 (identification of scallop sterols)
1527 (sterols of Crustacea)
1562 (stages of sexual development in Atl. salmon)
1576 (hormonal steroids in sturgeon plasma)
A 198 (stable protein from the sea)

Iioka, Chikara
T 236 (eggs & larvae of *Limanda yokohamae*)

Iles, Christine
J 28(1): 31 (swordfish parasites from NW Atl.)

Iles, Thomas Derrick
A 207 (Atl. herring fisheries)
208 (N.B. herring & sardines)

Illex illecebrosus (*see* Squid, shortfinned)

Illumination (*see* Bioluminescence; Darkness; Light, reactions to; Radiation; Vision)

Immunology (*see* Antibodies; Disease; Vaccination; Viruses)

Impoundment (*see* Culture; Dams)

Indexes
B 176 (to Canadian Arctic, Pac., & Atl. zooplankton)
T 209 (storage & retrieval of indexed & annotated bibliographical references)
246: 90 (bibliography of translation indexes, re N America Pac. coast trawled fishes)

Indicator species
J 28(1): 31 (*Tristoma* trematode species re swordfish populations)
T 202 (river diatoms re heavy-metal contamination of water)
A 181 (*Anisakis* roundworms & *Eubothrium crassum* tapeworm re geographical origin of Atl. salmon stocks)

Infection (*see also* Disease; Furunculosis; Parasites; Tumours; Viruses; Yeasts)
J 28(7): 1064 (pancreatic necrosis virus in brook trout; effect of stress on detecting bacterial or viral infections in fishes)
T 226 (shiners as possible immune carriers of *Aeromonas liquefaciens* bacteria disease to salmon & suckers, NW Miramichi R., N.B.)
A 58(F) human dermatitis from fluke larvae)
186 (infectious diseases of USSR fishes & control: book review)

Ingram, Peter
S 1458 (branching enzyme in trout liver)

Inia geoffrensis (*see* Dolphin, Amazon River)

Inlets (*see also* Oceanography *and* names of inlets)
J 28(8): 1077 (physical oceanographic features of 32 Chilean, & comparison with B.C./Alaska fiord inlets)

Inosine and derivatives
J 28(8): 1125 (5′-monophosphate degradation in skeletal muscle of Atl. fishes re keeping quality)

INPFC (*see* International North Pacific Fisheries Commission)

Insecticides (*see also* Pesticides; Pollution; Toxicants)
J 28(1): 59 (DDT residues in Canadian Atl. fishes & shellfishes tissues)
(1): 105 (DDT residues in Saskatchewan R. fishes muscle)
(4): 610 (dieldrin concentration in green sunfish blood & brain)
(4): 613 (anticholinesterase activity of several)
(5): 705 (biological magnification & degradation of DDT & aldrin by freshwater invertebrates)
(12): 1877 (DDT accumulation & persistence in a lotic ecosystem)
S 1463 (mass spectrometric identification of polychlorinated biphenyls & DDT in mixtures)
1536 (possible cause of deformed chironomids larvae in L. Erie & Okanagan R. lakes, B.C.)
1552 (decrease in DDT residues in Atl. salmon parr after N.B. forest spraying)

1558, 1570 (toxicity & uptake of polychlorinated biphenyls in sea water re *Gammarus oceanicus* amphipod)
A 201 (DDT re Great Lakes fishes as human food)
222 (DDT effects on physiology & behaviour of salmonids at sub-lethal levels)

Insects, aquatic (*see also* classifications; *also* Insecticides)
J 28(1): 35 (differences upstream & downstream of a dammed Ont. lake)
(1): 73 (ash & caloric content of some thermal spring)
(5): 705 (biological magnification & degradation of insecticides by)
(6): 849 (samplings from shallow stream beds)
(6): 928 (in feed of fluffy & tidepool sculpins)
(9): 1322 (quantitative sampler for forms on aquatic plants)
(11): 1715 (re L. Ontario bays benthos)
T 258 (toxicity tests of trisodium nitrilotriacetate detergent on larvae, re pollution)
S 1532, 1533 (chironomids, etc. in high mountain North Boulder Creek, Colorado)
1543 (Oligochaeta, Sphaeriidae & Chironomidae of Georgian Bay, L. Ontario, & L. Erie)

Instruments (*see* Apparatus)

International Commission for the Northwest Atlantic Fisheries (ICNAF)
T 270 (Canadian Atl. salmon catches by areas, 1950–69)
S 1492 (tagged haddock movements off Digby, N.S.)
1493 (assessments of mesh size increases of cod trawls)
1494 (growth & mortality estimating on basis of age–length keys)
1495 (Bay of Fundy immature herring populations)
1507 (haddock length conversion factors)
1540 (catch/effort assessments for major cod stocks)
1541 (trends in American plaice fishery, Nfld.)
1542 (temperatures & salinities in E Nfld. ICNAF area, 1969)
A 181, 182 (Canadian 1969 research report, Subareas 1–5)
191 (American plaice eggs & larvae)
206 (haddock recruitment & stock abundance, 1970–72)
207 (recent events in Canadian Atl. herring fisheries)
208 (vertebral numbers of Bay of Fundy herring; origin of N.B. sardines)

International North Pacific Fisheries Commission (INPFC)
A 204 (salmons & steelhead trout longline fishing, tagging, racial, & oceanographic FRB studies, 1965)

Interrenal tissue (*see also* Kidney; Pituitary gland)
J 28(4): 477 (histological effects of hormones & cortisol on gonadectomized sockeye salmon)
S 1478, 1479 (histological identification in Atl. sturgeon re steroidogenesis)

Intestinal tract (*see* Feed; Digestion)

Introduced species (*see* Species, introduced; Transplantation)

Invertebrates (freshwater in general) (*see also* Benthos; Insects, aquatic; *also* classifications and names of species)
J 28(5): 705 (biological magnification & degradation of insecticides by)
(6): 849 (sampling benthos in shallow streams)
(8): 1205 (2 simple epifaunal collectors)
(11): 1683 (benthic macroinvertebrates associations & species diversity in L. Ontario bays)
(11): 1699 (benthic macroinvertebrate production, L. Ontario bays)
(11): 1715 (benthos community metabolism, L. Ontario bays)
(12): 1877 (DDT accumulation & persistence in)
S 1532, 1533 (in high mountain North Boulder Creek, Colorado)
A 224 (parasites of N American, USSR, & European coregonid fishes)

Invertebrates (marine in general) (*see also* Benthos; *also* classifications and names of species)
J 28(8): 1167 (details of winter flounder stomach contents)
(8): 1205 (2 simple epifaunal collectors)
(10): 1583 (possibilities of speciation by X-ray irradiation spectra)
(12): 1877 (DDT accumulation & persistence in)
B 176 (synopsis of Canadian Arctic, Pac., & Atl. marine zooplankton; see index of that Bulletin)
T 225 (associated with Bay of Fundy scallop beds)
266, 267 (zooplankton & phytoplankton, Frobisher Bay, Baffin Is., N.W.T.)
S 1580 (classification & ordination of many shallow benthic species, P.E.I.)

Iredale, David Gordon
J 28(7): 1061 (method of drying freshwater fish)

Iron derivatives
J 28(1): 47 (hemosiderin as storage form of, in fish spleen, kidney, & liver tissues)
(2): 171, 203 (in waters of many small NW Ont. lakes)
(2): 203 (re photosynthesis by plankton in samples of water from small NW Ont. lakes)
(2): 277 (in sediments of 16 small NW Ont. lakes)
(6): 843 (level in P.E.I. oysters)
S 1529 (distribution in L. Ontario)
A 199 (re Gulf of St. Lawrence marine sediments geology)

232 (^{55}Fe as radioactive marine pollutant)

Irradiation (*see also* Light, reactions to; Radiation; Radioactivity; X-rays)
J 28(5): 643 (by ^{60}Co for killing *Salmonella* bacteria in smoked fish)
S 1460 (bacterial spoilage of haddock re pre-irradiation quality)

Irwin, Brian
T 247 (phytoplankton production & nutrients in Bedford Basin)

Isoenzymes (*see* Enzymes)

Isopiestic measurements
S 1512, 1515 (re activity coefficients of H_2O–NaCl–$MgCl_2$ (& –Na_2SO_4) ternary systems at 25 C)

Isopoda
J 28(6): 928 (feed of tidepool & fluffy sculpins)
T 266 (Frobisher Bay, Baffin Is., N.W.T.)

Isopropanol (*see* Alcohols)

Isopsetta isolepis (*see* Sole, butter)

Isotopes (radioactive) (*see also* Radioactivity; *also* names of elements) (*Note:* data on use of ^{14}C are, with few exceptions, not indexed because of its frequent use; *see* Photoiosynthesis)
J 28(5): 769 (liquid scintillation assay method for ^{14}C-labelled benthic microflora)
(3): 369; (10): 1583 (re radioisotope X-ray fluorescence spectrometry)
A 232 (as radioactive marine environment pollutants)

Isozymes (*see* Enzymes)

Isurus oxyrinchus (*see* Mako, shortfin)

Itch, swimmers' and clam diggers'
A 58(F) (cause, control, & treatment)

Ito, Jun
J 28(12): 1921 (herring predators on young salmon)

J

Jamieson, William David
S 1463 (identification of polychlorinated biphenyls & DDT)

Jangaard, Peter Michael
A 214 (hormone research in fish farming)
215 (review of book on fishery by-products technology)
220 (FRB scientists' role in research cruise)

Japan
T 246 (bibliography of trawl fishery off N America Pac. coast)

Jasper National Park, Alta.
J 28(3): 311 (crustacean plankton of 57 alpine & subalpine lakes & ponds)

Jaw (*see also* Morphology (biological))
J 28(10): 1545 (abnormalities of Pac. herring larvae, raised at elevated temperatures, & possible detriment to adult feeding)
S 1514 (fat of Amazon R. dolphin re echolocation ability)

Jellyfish
J 28(10): 1595 (*Vellela* concept behaviour re Chondrophora evolution)

Jenkins, Thomas Mandeville, Jr.
J 28(7): 1019 (social behaviour re introduced rainbow trout)

Jensen, Alvin Lee
J 28(3): 458 (response of brook trout populations to a fishery)

Johnson, Bernard Gugy Herbert
S 1484 (molecular structure & biological activity among mononitrophenols containing halogens)

Johnson, Byron Thomas
J 28(5): 705 (pesticide accumulation in invertebrates)

Johnson, Lionel
T 165(F) (central Canada rainbow trout farming)

Johnson, Murray George
J 28(11): 1683 (L. Ontario benthos species diversity)
(11): 1699 (L. Ontario benthos production)
(11): 1715 (L. Ontario benthos community metabolism)

Johnson, Waldo Eugene
J 28(2): 123 (background of FRB Experimental lakes, NW Ont.)
A 233 (ecology and our pollution problems)

Jonas, Richard Edmund Ernest
J 28(7): 1015 (trout lysosomal lipase)
(12): 1837 (tissue solubilization by lysolecithin)

Jones, Bernard Raymond
J 28(6): 924 (temperature requirements for larval ciscos)

Jones, Meredith Leam
J 28(10): 1445 (new species and redescriptions of *Magelona*)

Jones, Robert Andrew
J 28(8): 1167 (net avoidance behaviour in shad)

Jørgensen, Poul Erik Vestergård
J 28(6): 875 (rainbow trout antibodies to Egtved virus)

Juan de Fuca Strait (*see also* Georgia, Strait of; Oceanography, Pacific east coast)
T 210 (oceanography & groundfish catches during trawling survey, 1970)

K

"K-line" (*see also* Growth)
J 28(6): 801, 809, 815 (re growth efficiency analysis)

Kabata, Zbigniew
J 28(8): 1143 (locomotion in Caligidae)
(10): 1563 (Bomolochidae from B.C. fishes)
S 1496 (new species of copepod from India)
1501 (haemobaphes in B.C.)
1566 (new female parasitic copepod in Indian Ocean)
1567 (Crustacea as enemies of fishes)
1568 (Copepoda parasitic on Australian fishes)
A 186 (control of infectious disease in fish)

Karuppannan, Nalliggoundanoor Vealappagounder
J 28(9): 1342 (technique for measurement of carbon dioxide in fish)

Karyotypes (*see* Chromosomes)

Kason, William Rudolf
S 1531 (casein and polyethylenimine)

Katodinium auratum (*see* Dinoflagellates)

Katsuwonus (*see* Tuna, skipjack)

Kaye, Clifford Alan
S 1511 (European flints on N American coast)

Ke, Paul Jean
J 28(7): 1055 (distillation of fluoride in soils)
T 233 (possible toxic materials in Nfld. bottom deposits)
S 1505 (fluoride in polluted waters)
1572 (distribution of fatty acids in lipids of 3 species of molluscs)

Keleher, James John
T 176 (bibliography of lake trout 1929–1969)

Kennedy, Victor Samuel
J 28(8): 1153 (Nfld. winter flounder)

Kennedy, William Alexander
T 243 (1970 sablefish culture progress)

Kern River Basin, California
J 28(7): 987 (systematics & evolution of *Salmo* species & subspecies of Upper Basin, re western N America *Salmo*)

Kerr, Stephen Roy
J 28(6): 801 (analysis of laboratory experiments on growth efficiency of fishes)
(6): 809 (prediction of fish growth efficiency in nature)
(6): 815 (simulation model of lake trout growth)

Kerswill, Charles James
J 28(3): 351 (Miramichi salmon smolt utilization)
MSP 13(F) (studies in Canada's Arctic)

Keyhole Lake, Victoria Island, Canadian Arctic)
T 231 (potential productivity of arctic char, from limnological & biological studies)

Keys
J 28(3): 401 (*Mesodinium* red-water ciliates)
(4): 543 (Canadian freshwater leeches (Hirudinoidea))
(10): 1469 (*Syllides* polychaetes)
(10): 1407 (genera in Fauveliopsidae, a new family of polychaetous annelids)
(10): 1645 (*Rhabdochona* nematode species parasitic in N & Central America fishes)
T 246 : 89 (bibliography of, for trawl fishes off N America Pac. coast)
S 1494 (behaviour of growth & mortality estimates based on age–length keys)
1543 (tubificid oligochaetes of E North America)

Keyte, Freeman Kilbourne
T 271 (Gulf of St. Lawrence circulation patterns)

Khan, Nuzrat Yar
J 28(4): 465 (lake char postglacial distribution)

Kidney (*see also* Interrenal tissue)
J 28(1): 47 (hemosiderin bodies re erythropoiesis in blue gourami)
(1): 112 (histology of cutthroat trout with leukemia condition)
(4): 485 (histological effects of hormones & cortisol on gonadectomized adult sockeye salmon)
(6): 843 (zinc level in rat, when fed P.E.I. oysters)
(7): 1064 (vs. feces re presence of pancreatic necrosis virus in brook trout)
(12): 1837 (lysolecithin solubilizing effect on extractability of tissues, in rainbow trout)

Kiley, Charles Walter
J 28(1): 47 (erythropoiesis in *Trichogaster trichopterus*)

Killifish, banded (*Fundulus diaphanus*)
T 261 (bibliography for Gulf of St. Lawrence)

Killifish, striped (*Fundulus majalis*)
J 28(8): 1208 ("hemagglutinogens")
(9): 1225 (cadmium toxicity tests)

Kittelsen, Arne
J 28(12): 1918 (abnormalities in trout)

Knight, William
S 1494 (growth & mortality estimates)

Knox, D. F.
J 28(11): 1815 (dispenser for oxygen reagents)

Knox, George Alexander
J 28(10): 1437 (*Dodecaceria berkeleyi* n.sp.)

Kohler, Allan Carl
J 28(9): 1285 (methylmercury in fish)

Kokanee (*Oncorhynchus nerka* (*kennerlyi*)) (non-anadromous sockeye salmon) (*see also* Salmon, sockeye)
J 28(4): 573 (technique & computer programming for enumerating fry migrating through streams)
(12): 1857 (introduction into L. Huron; spawning)

Kootenay Lake, B.C.
T 245 : 1 (mass mortality of mountain whitefish); 7 (disease in rainbow trout run)

Kooyman, Albertus Hermanus
J 28(7): 1005 (walleye malate dehydrogenase)

Korea
T 246 (bibliography of trawl fishery off N America Pac. coast)

Kramer, Donald Emerson
T 220 (storage of Pac. salmon at sea)

Kramer, Robert Henry
J 28(4): 587 (factors influencing rainbow trout metabolism)

Kristiansen, Ulf Bo Gjerulff
T 210 (*G. B. Reed* groundfish cruise 70–2)
269 (*G. B. Reed* groundfish cruise 71–1)

Kuhns, William Joseph
J 28(8): 1208 (killifish "hemagglutinogens")

Kutty, Methil Narayanan
J 28(9): 1342 (technique for measurement of carbon dioxide in fish)

Kwain, Wen-hwa
J 28(5): 771 (life history of L. Superior rainbow trout)

L

Labrador (*see also* Newfoundland)
T 270 (Atl. salmon catches, 1956–69)
A 195 (fisheries)

Labrifer balli (*see* Flukes)

Lacroix, Guy
J 28(8): 1205 (epifaunal collectors)

Lactate (*see also* Enzymes; Metabolism; Physiology)
J 28(5): 625, 635 (levels in brook trout blood from handling & anesthetization)
(8): 1215 (changes in blood lactic acid concentration of alewives passing through a pool & weir fishway)
(11): 1745 (serum & muscle dehydrogenases in suckers)

Ladders, fish (*see* Fishways)

Ladysmith Harbour, B.C.
B 178 (raft-culturing of Pac. oyster)

Lagenorhynchus obliquidens (*see* Porpoise, Pacific white-sided)

Lake... (*see* name of lake)

Lakes (*see also* Eutrophication; Limnology; Pollution; *also* names of lakes)
J 28(2): entire issue (FRB Experimental Lakes Area program re biological productivity & eutrophication of 463 small NW Ont. lakes)
(3): 311 (crustacean plankton of 146 W Canadian alpine & subalpine lakes & ponds)
(11): 1763 (eutrophication of one of Experimental Lakes Area lakes by addition of phosphate & nitrate)
(12): 1883 (limnology of 51 on Manitoulin Is. (L. Huron))

Lamellibranchs (*see* Pelecypoda)

Laminaria (*see* Seaweeds)

Lamna nasus (*see* Porbeagle)

Lampetra lamottei (*see* Lamprey, American brook)
tridentatus (*see* Lamprey, Pacific)

Lamprey, American brook (*Lampetra lamottei*)
J 28(4): 616 (sizes of 5 giant, probably parasitic, females from upper Great Lakes, re average adult size of non-parasitic ordinary type)

Lamprey, chestnut (*Ichthyomyzon castaneus*)
J 28(4): 616 (size re giant American brook lampreys, upper Great Lakes)

Lamprey, Ohio (*Ichthyomyzon bdellium*)
J 28(4): 616 (size re giant American brook lampreys, upper Great Lakes)

Lamprey, Pacific (*Entosphenus* (*Lampetra*) *tridentatus*)
T 221 (taken in B.C. groundfish surveys)

Lamprey, sea (landlocked) (*Petromyzon marinus*)
J 28(1): 65 (effect on L. Superior lake trout populations)
(5): 771 (parasitism on rainbow trout, Batchawana Bay, L. Superior)
S 1484 (molecular structure of halogenated mononitrophenols re their toxicity to larvae)
1490 (history of invading Great Lakes, damage to fisheries, & controlling the infestation)

Lamprey, sea (marine) (*Petromyzon marinus*)
T 261 (bibliography for Gulf of St. Lawrence)

Lamprey, silver (*Ichthyomyzon unicuspis*)
J 28(4): 616 (size re giant American brook lampreys, upper Great Lakes)

Lance, American sand (*Ammodytes americanus*) (sand launce)
J 28(4): 601 (fatty acid composition of oils & phospholipids)
T 252 (distribution off southern N.S. coast)
260 (standing crop, availability, lengths, weights, etc. from Scotian Shelf surveys, 1958–68)
261 (bibliography for Gulf of St. Lawrence)
S 1591 (pristane & other hydrocarbons in commercial oil)
A 182 (ICNAF Canadian 1969 research summary)

Lance, northern sand (*Ammodytes dubius*)
T 261 (bibliography for Gulf of St. Lawrence)

Lance, Pacific sand (*Ammodytes hexapterus*) (sand launce)
T 221 (taken in B.C. groundfish surveys)
257 (taken in B.C. & U.S. Pac. coast commercial trawling, 1970)

Lancetfish, scaled (*Paralepis coregonoides borealis*)
J 28(8): 1199 (as Atl. salmon feed in Davis Strait & Labrador Sea)

Landings (*see* Catches; Fisheries)

Lanternfish, glacier (*Benthosema glaciale*)
T 261 (bibliography for Gulf of St. Lawrence)
A 182 (ICNAF Canadian research, 1969)

Lanternfish, Krøyer's (*Notoscopelus krøyeri*)
T 261 (bibliography for Gulf of St. Lawrence)

Lanternfish, spotted (*Myctophum punctatum*)
T 261 (bibliography for Gulf of St. Lawrence)

Lanternfishes (Pacific) (*see also* names of species)
T 221 (taken during B.C. groundfish surveys)

Lantz, Andrew William
J 28(7): 1061 (method of drying freshwater fish)

Lapi, Louis Antinino
J 28(10): 1583 (X-ray spectrometry)

Laqueus californianus (Brachiopoda)
T 268 (in B.C. faunistic surveys since 1960)

Larkin, Peter Anthony
J 28(6): 821 (gillnet selectivity on sockeye & pink Skeena R. salmon)
(10): 1493 (sockeye simulation studies)

Larus argentatus (*see* Gull, herring)

Larvae (*see* Development; *also* name of adult form of animal)
J 28(1): 73 (energetics & natural history of dipteran *Hedriodiscus truquii* in thermal springs)
B 176 (synopsis of literature to end of 1970 re larval forms in Canadian marine zooplankton; includes an index)

Larvicides (*see* Insecticides; Piscicides)

Lau, Yan Chee
J 28(7): 1015 (trout lysosomal lipase)

Laubier, Lucien
J 28(10): 1483 (*Schroederella berkeleyi*, sp.n.)

Launce, sand (*see* Lance)

Lawler, George Herbert
T 165(F) (central Canada rainbow trout farming)
A 224 (parasites of coregonid fishes)

Lawrie, Andrew Hampton
S 1490 (sea lamprey in Great Lakes)

Laycock, Rosemary Anitra
J 28(3): 305 (haddock fillets bacteria)
S 1460 (spoilage of irradiated haddock)

Lead derivatives
J 28(5): 786 (in dressed Canadian fishes from industrial area lakes)
S 1529 (distribution in L. Ontario)

Lear, William Henry
J 28(3): 461 (record of Atl. menhaden from Northumberland Strait)
(8): 1199 (salmon specimens from Davis Strait & Labrador Sea)
T 270 (digest of Canadian Atl. salmon catch statistics)
A 190 (Greenland halibut)

LeBrasseur, Robin John
A 188 (marine biology in Saanich Inlet)
211 (availability of food in marine food chain)

Lecithins
J 28(12): 1837 (lysolecithin solubilizing effect on extractability of various rainbow trout tissues)
S 1474 (fatty acid composition in rainbow smelts)

Lecithophyllum botryophorum (*see* Flukes)

Lee, Jong Sun
J 28(11): 1789 (interaction between paralytic shellfish poison and melanin)

Lee, Pei Jen
T 209 (filing bibliographic references)
244 (multivariate analysis for fisheries biology)
250 (fish catch & pollution principle & operation)

Leeches (Herudinea)
J 28(4): 543 (key to Canadian freshwater)
A 224 (parasitic to N American, USSR, & European coregonid fishes)

Leggett, William Claude
J 28(8): 1167 (net avoidance behaviour in shad)

Lenarz, William Henry
J 28(3): 446 (electronic processing of acoustical data for fishery research)

Length (*see also* Age; Growth; Size; Weight)
J 28(4): 513 (successive Skeena R. sockeye salmon generations re egg weight & progeny size)
(6): 861 (feeding level effects on young sockeye salmon)
(7): 935 (frequency or range, of 20 Passamaquoddy Bay, N.B., fish communities participants)
(7): 971 (*Sagitta elegans* arrow worms, re growth & temperature, St. Margaret's Bay, N.S.)
(7): 1009 (re S Gulf of St. Lawrence seasonal herring stocks discreteness)
(9): 1309 (re age, white whale)
(10): 1621 (re age, northern rockfish)
T 213 (distribution, B.C. offshore herring)
232 (razor clams)
237 (re weight of Pac. ocean perch off B.C. in 1969)
250 (computer programming fish fork length data)
251 (re girth of Pac. ocean perch off B.C. in 1969)
259 (re age, B.C. rock sole)
260 (groundfish species, Scotian Shelf, from 1958–68 surveys)
S 1492 (tagged & commercially landed haddock, 1963–66)
1493 (Atl. cod, re changes in trawl net mesh sizes)
1494 (behaviour of growth & mortality estimates based on age–length keys)
1495 (frequencies, in Bay of Fundy immature herring populations)
1507 (conversion factors for haddock standard, extreme total & fork lengths)

Lepeophtheirus (parasitic copepods)
J 28(3): 323 (morphology & new nomenclature as parasites of ocean sunfish; world distribution of *L. nordmanni* & *L. hastatus*)
(8): 1143 (*L. salmonis* locomotory mechanisms)

Lepidion (morid fishes)
T 160 (*L. eques, L. lepidion, L. güntheri* & *L. schmidti* meristic, morphometric, weight, feed, & parasites data)

Lepidopsetta bilineata (*see* Sole, rock)

Lepisosteus osseus (*see* Gar, longnose)

Lepomis auritus (*see* Sunfish, redbreast)
cyanellus (*see* Sunfish, green)
gibbosus (*see* Pumpkinseed)
macrochirus (*see* Bluegill)

Leptocottus armatus (*see* Sculpin, Pacific staghorn)

Lernaeopodidae (*see also* Copepoda)
S 1496 (new parasitic genus & species, *Proclavellodes pillaii*, from S India fish)
1501 (new parasitic species, *Haemobaphes intermedius;* also description of *H. diceraus*, from Strait of Georgia)
1566 (new parasitic species, *Lernanthropus togatus*, on gills of marine Kenyan fish *Gaterin*)

Lesion (*see* Pathology)

Lethal limits (*see also* Insecticides; Pesticides; Piscicides; Pollution; Toxicants; *also* factors influencing; e.g., Oxygen, dissolved; Respiration; Salinity, reactions to; Temperature, reactions to)
B 177 (paralytic shellfish toxin to man, mice, domestic animals & birds)
S 1590 : 522 (of temperature to various fishes: review)

Leucichthys (*see Coregonus*)

Leukemia (*see* Blood)

Levenstein, Raisa Yakovlevna
J 28(10): 1429 (*Macellicephaloides berkeleyi* n.sp.)

Abbreviations: J — *Journal.* B — *Bulletin.* AR — *Annual Report.* R — *Review. Circular Series:* CHN — Halifax; CNG — Nanaimo; CJG — St. John's. T — *Technical Reports.* MSP — *Miscellaneous Special Publications.* S — *Studies.* A — *Interpretive Articles.*

Li, Ming Fang
J 28(1): 104 (skin lesions of rainbow trout)

Lice, aquatic (*see* Amphipoda; Copepoda; Parasites)

Life history (*see also* aspects of; *also* names of organisms)
J 28(1): 73 (*Hedriodiscus truquii* diptera in thermal springs)
(5): 771 (rainbow trout, Batchawana Bay, L. Superior)
(7): 971 (*Sagitta elegans* chaetognath, St. Margaret's Bay, N.S.)
T 231 (arctic char in a small arctic lake)
S 1501 (*Haemobaphes* parasitic copepods)
A 184 (harp & ringed seals)

Life span
J 28(10): 1573 (re animal production–biomass ratio)

Light, polarized (*see* Light, reactions to; Migration)

Light, production of (*see* Bioluminescence)

Light, reactions to (*see also* Darkness; Diel habits; Radiation; Vision)
J 28(4): 587 (re wild vs. hatchery rainbow trout metabolism)
(6): 919 (prespawning brook sticklebacks)
(9): 1303 effects of oxygen depletion & carbon dioxide accumulation on walleye photic behaviour)
(9): 1352 (increased predation of torrent sculpin on moonlight nights)
(9): 1319 (polarized; perception by yearling sockeye salmon, re migration)
(11): 1749, 1757 (photoperiods effect on young sockeye salmon scale growth after starvation periods)
S 1486 (newly hatched crayfish)
1557 (re crayfish ovarian maturation & egg laying)

Liley, Nicholas Robin
S 1535 (sexual behaviour of female guppy)

Limanda aspera (*see* Sole, yellowfin)
ferruginea (*see* Flounder, yellowtail)
yokohamae (*see* Dab, mud)

Limnocalanus (*see* Copepoda)

Limnodrilus hoffmeisteri (tubificid oligochaete)
J 28(3): 335 (survival of bacteria during ingestion by, in Toronto Harbour, Ont., sediments)

Limnology (*see also* Benthos; Eutrophication; Lakes; Pollution; Ponds; Sediments; *also* names of lakes)
J 28(1): 102 (plotting bathythermograph transect data on a computer printer)
(2): entire issue (FRB Experimental Lakes Area studies of many small NW Ont. lakes)
(5): 765 (rapid ammonium ion determination method for waters)
(11): 1683, 1699, 1715 (Bay of Quinte & other L. Ontario bays)
(12): 1883 (physical & chemical aspects of 51 Manitoulin Is. (L. Huron) lakes)
T 165(F) (re rainbow trout farming in central Canada)
231 (Keyhole L., Canadian Arctic, re arctic char potential production)
MSP 13(F) (summary of FRB investigations in Canadian Arctic)
S 1532, 1533 (North Boulder Creek, Colorado, re invertebrates in this high mountain area)

Lindsey, Casimir Charles
J 28(9): 1235 (medaka vertebral count re egg size)

Lingcod (*Ophiodon elongatus*)
T 216, 257 (catches during B.C. & U.S. Pac. coast commercial trawling, 1969, 1970)
221 (catches during B.C. groundfish surveys)
246 (bibliography)
S 1523 (muscle purine & pyrimidine nucleoside phosphorylases)
1524 (muscle guanine deaminase mechanism & specificity)

Liopsetta putnami (*see* Flounder, smooth)

Liparis atlanticus (*see* Seasnail (Atlantic))
cyclostigma (*see* Seasnail, polka-dot)
koefoedi (*see* Seasnail, gelatinous)
liparis (*see* Seasnail, striped)
tunicatus (*see* Seasnail, Greenland)

Lipases (*see* Enzymes)

Lipids (*see also* Acids, fatty; Composition, chemical; Oils and fats; Phospholipids)
J 28(1): 7 (seasonal changes in total, of freshwater triclad flatworm)
(4): 601 (fatty acids of sand lance)
(5): 776 (content of *Pontoporeia affinis* amphipod, Cayuga L., N.Y.)
S 1461 (esters fatty acid structure influence on pancreatic lipase activity)
1474 (fatty acid composition in rainbow smelts)
1475 (confusion between C_{18} & C_{20} fatty acids in analysis of water-plant seed lipids)
1564 (*trans*-6-hexadecenoic acid & corresponding alcohol in sea urchin *Metridium dianthus;* also fatty acids composition of lipids)
1572 (saturated & isoprenoid fatty acids distribution in periwinkle, Atl. oyster & quahaug)

Lipps, Jere Henry
S 1587 (pleistocene paleoecology & biostratigraphy, Santa Barbara Is., Calif.)

Lister, David Brent
J 28(5): 647 (pink salmon in Qualicum R.)

Lists of organisms (*see* Benthos; Checklists; Fauna; Fishes, lists of; Invertebrates; *also* names of some classifications of organisms)

Lists of publications (*see* Publications, lists of; Publications and Reports, FRB)

Litchfield, Carter
S 1514 (lipids of Amazon R. dolphins)

Lithium derivatives
J 28(2): 277 (in sediments of 4 small NW Ont. lakes)

Lithodes (crabs)
J 28(10): 1527 (*L. couesi* first record off B.C.)

Littorina littorea (*see* Periwinkle, common)

Liver (*see also* Liver Oils)
J 28(1): 47 (hemosiderin bodies re erythropoiesis in blue gourami)
(1): 112 (histology of cutthroat trout with leukemia condition)
(4): 485 (histological effects of hormones & cortisol on gonadectomized adult sockeye salmon)
(6): 843 (zinc level in rat, when fed P.E.I. oysters)
(7): 1053 (genic polymorphism of tetrazolium oxidase in bluefin tuna)
(7): 1064 (vs. feces re presence of pancreatic necrosis virus in brook trout)
(11): 1793 (*see* T 229 below)
(12): 1837 (lysolecithin solubilizing effect on extractability of tissues, in rainbow trout)
T 229 (feeding rats raw or partially hydrogenated Atl. herring oil re fat deposition in)
S 1458 (glycosyl transferase re glycogen structure in rainbow trout liver)

Liver oils
S 1591 (pristane & other hydrocarbons in commercial Canadian Atl. cod & Pac. spiny dogfish)

Lobster, American (*Homarus americanus*)
J 28(1): 15 (esterase isozymes polymorphisms)
(1): 59 (DDT residues in N.B.)
(5): 793 (yellow phosphorus accumulation in various tissues)
(6): 879 (enolase enzyme isolation & comparison with other enolases re phylogeny)
(7): 1062 (sensor apparatus for detecting presence in burrow)
(9): 1285 (methylmercury in, off N.S.)
(11): 1733 (production potential re seaweed production & feed, St. Margaret's Bay, N.S.)
CHN 41, 42 (nature & control of gaffkemia disease)
T 217 (pollution from petroleum oil spills)
235 (agonistic behaviour)
S 1527 (muscle sterols)
1569 (determination of residual fuel oil contamination in abdominal muscle, claw muscle, gut, & stomach)
A 180 (gaffkemia disease cause & pathology in)
194, 195 (Nfld. & Labrador fishery)
200 (mercury contamination)
213 & 213(F) (artificial rearing of)

Lobster, spiny (*Palinurus argus*)
S 1527 (muscle sterols)

"Lobster disease" (*see* Gaffkemia)

Locomotion
J 28(7): 1062 (sensor apparatus for detecting lobster in a burrow)
(8): 1143 (mechanisms of 2 parasitic copepods)
S 1551 (development in postlarval *Macoma balthica* clam)

Locomotor responses (*see* Light, responses to; Light, reactions to; Odour and reactions to; Salinity, reactions to; Swimming; Temperature, reactions to; Vision)

Loligo opalescens (*see* Squid, longfinned (Pacific))
peali (*see* Squid, longfinned (Atlantic))

Long Bay; Long Harbour, Nfld. (*see* Placentia Bay, Nfld.)

Long Beach, Vancouver Island, B.C.
T 232 (razor clam breeding & growth)

Lophius americanu (*see* Goosefish)

Lopholithodes mandtii (*see* Crab, box)

Loring, Douglas Howard
S 1511 (European flints on N American coast)
A 199 (marine geological investigations in Gulf of St. Lawrence)

Lota lota (*see* Burbot)

Loucks, Ronald Harold
S 1482 (study of eutrophicated marine basin)

Love, John
S 1522 (optical detection pressure apparatus)

Luhning, Charles William
J 28(1): 113 (tricaine methanesulfonate in fish muscle)

Luminescence (*see* Bioluminescence)

Lumpenus fabricii (*see* Eelblenny, slender)
lumpretaeformis (*see* Snakeblenny)
maculatus (*see* Shanny, daubed)
medius (*see* Eelblenny, stout)

Lumpfish (*Cyclopterus lumpus*)
J 28(7): 935 (occasional component of Passamaquoddy Bay fish communities, N.B.)
(9): 1285 (methylmercury in, N.S. banks)
T 261 (bibliography for Gulf of St. Lawrence)

Lumpsucker, Atlantic spiny (*Eumicrotremus spinosus*)
T 261 (bibliography for Gulf of St. Lawrence)

Lunatia heros (*see* Clam drill, greater)

Lutetium
A 232 (^{177}Lu as radioactive marine pollutant)

Lux, Fred Edward
S 1492 (growth of American plaice)

Lycenchelys paxillus (*see* Wolf-eel (Atlantic))

Lycodes atlanticus (*see* Eelpouts (Atlantic))
esmarki (*see* Eelpouts (Atlantic))
lavalaei (*see* Eelpout, Newfoundland)
pallidus (*see* Eelpout, pale)
reticulatus (*see* Eelpout, arctic)
seminudus (*see* Eelpouts (Atlantic))
turneri (*see* Eelpout, polar)
vahlii (*see* Eelpout, Vahl's)

Lycodopsis pacifica (*see* Eelpout, blackbelly)

Lymnaea (*see* Snails), freshwater))

Lymphocystis viral disease (*see* Disease)

Lyopsetta exilis (*see* Sole, slender)

Lysolecithin
J 28(12): 1837 (solubilizing effect on extractability of various rainbow trout tissues)

M

MacAskie, Ian Bruce
J 28(4): 620 (range extension for squid)
A 209 (sea otter transplant to B.C.)

MacCrimmon, Hugh Ross
J 28(3): 452 (world distribution of brook trout, further observations)
(5): 663 (rainbow trout world range)

Macdonaldia challengeri (*see* Eel, deepsea spiny)

Macellicephaloides berkeleyi (aphroditid polychaete)
J 28(10): 1429 (new species, from Aleutian trench)

MacKelvie, Robin Maxwell
J 28(1): 100 (removal of embryos from fish eggs)

Mackerel, Atlantic (*Scomber scombrus*)
J 28(1): 59 (DDT residues in N.B.)
(7): 947 (blood pathway effects on blood-pressure drop in gills)
T 261 (bibliography for Gulf of St. Lawrence)
A 182 (ICNAF Canadian 1969 research summary)

Mackerel, chub (*Scomber japonicus*) (*S. colias*)
T 261 (bibliography for Gulf of St. Lawrence)

Mackie, George Owen
J 28(10): 1595 (studies on evolution of Chondrophora)

Mackie, Gerald Lloyd
J 28(9): 1322 (quantitative sampler for aquatic phytomacrofauna)

MacLean, James Alexander
J 28(6): 919 (temperature effects on prespawning Man. sticklebacks)

MacNeill, Ian Bruce
J 28(7): 1035 (fish count sequences)

Macoma balthica (*see* Clams)

Macrophytes, aquatic (*see* Eelgrass; Seaweeds)

Macrourus berglax (*see* Grenadier, roughhead)
rupestris (*see* Grenadier)

Macrozoarces americanus (*see* Pout, ocean)

Mactra solidissima (*see* Clam, bar)

Madden, Jane Anne
J 28(5): 625 (handling & anesthetization effects on brook trout)
(5): 635 (brook trout variations re surgery)

Magelona (polychaetes)
J 28(10): 1445 (*M. berkeleyi:* new species, Puget Sound; *M. longicornis* redescription; other recently described species)

Magnesium derivatives
J 23(2): 171, 203 (in waters of many small NW Ont. lakes)
(2): 277 (in sediments of 16 small NW Ont. lakes)
(5): 625, 635 (level changes in brook trout after handling, anesthetization, & surgery)
S 1512 (isopiestic measurements on ternary system solutions re $MgSO_4$ activity coefficient)

Makaira audax (*see* Marlin, striped)
nigricans (*see* Marlin, blue)

Mako (*see* Mako, shortfin)

Mako, shortfin (*Isurus oxyrinchus*) (mako; mako shark)
A 182 (ICNAF Canadian 1969 research summary)

Malacoceros indicus (spionid polychaete)
J 28(10): 1455 (redescription of)

Malacology (*see* Mollusca)

Malate (*see also* Enzymes)
J 28(7): 1005 (dehydrogenase isozyme multiplicity in walleye skeletal muscle, re genetics)

Malformation (*see* Abnormality)

Mallotus villosus (*see* Capelin (Atlantic); Capelin (Pacific))

Mammals (general)
A 229 (aging by teeth & bone layered structure: book review)

Mammals, marine (*see* Beluga; Dolphin; Narwhal; Porpoise; Seal; Whale)

Man
B 177 (susceptibility to paralytic shellfish poisoning)
A 230 (ecosystems, pollution, etc., re a northern environment as sources of food)
232 (evaluation of radiation exposure from consumption of radioactive pollutants in marine foods)

Management, fisheries (*see also* names of International Commissions)
J 28(10): 1493 (re Adams R. sockeye salmon abundance fluctuations)
B 175 (economic study of Maritime Provinces oyster fishery)
177 (re paralytic shellfish toxicity in E Canada)
T 222 (genetics & mariculture re managed fishery populations)
246 (bibliography, N America Pac. coast trawl fisheries)
256 (Georges Bank scallop fishery suggestions)
A 183 (re utilization of ocean resources & oceanography)
192 (N Atl. salmon multilateral)
230 (of fisheries & other human food resources from a northern environment, re ecosystems & pollution)

Manganese derivatives
J 28(2): 277 (in sediments of 16 small NW Ont. lakes)
(5): 786 (in dressed Canadian fishes from industrial area lakes)
(6): 843 (level in P.E.I. Oysters)
S 1529 (distribution in L. Ontario)
A 232 (^{54}Mn as radioactive marine pollutant)

Manion, Patrick James
J 28(4): 616 (giant American brook lampreys in upper Great Lakes)

Manitoba (*see also* Moose Lake; Winnipeg, Lake; also other localities and bodies of water)
A 200 (mercury contamination of fishes in lakes & Hudson Bay)

Manitoulin Island, Lake Huron
J 28(12): 1883 (physical & chemical limnological aspects of 51 lakes)

Mann, John Howard
T 220, 242 (storage of Pac. salmon at sea)

Mann, Kenneth Henry
J 28(5): 778 (relation between stipe length, etc. of *Laminaria*)
(11): 1733 (productivity of seaweed–lobster communities)
S 1482 (study of eutrophicated marine basin)
A 223 (combating pollution on Canada's E coast)

Manohar, Shiriram Vajudeo
J 28(9): 1325 (postmortem changes in fish muscle)

Mansfield, Arthur Walter
J 28(12): 1873 (bowhead whale in Canadian arctic waters)
S 1573 (harbour seal in Thlewiaza R., N.W.T.)
A 184 (population dynamics & exploitation of some arctic seals)
228 (review of book on Jakob Danielsen's Greenlandic paintings)

Mantle
B 177 (of shellfishes, re paralytic shellfish toxicity)
S 1551 (development in postlarval *Macoma balthica* clam)

Marcy, Barton C., Jr.
J 28(7): 1057 (survival of fish in nuclear power plant discharge water)

Margaree Harbour, N.S.
S 1539 (capacity to accept pollutants)

Margarine
T 249 (detection & estimation of marine oil adulteration)

Margolis, Leo
J 28(10): 1385 (larval helminths in polychaetes)
S 1487 (nematode diseases of marine fishes)
1499 (redescription of syntypes of *Caligus rapax*)

Maria (*see* Burbot)

Mariculture (*see also* Culture; Feed; Hatcheries; Management; Oyster; Rations)
T 222 (re genetics)

Marion Lake, B.C.
J 28(1): 49 (comparison of 2 salamander populations)
(5): 711 (energy flow & secondary production of 2 amphipod species)
(9): 1259 (segregation between adult cutthroat & Dolly Varden trouts)

Maritime Provinces, Canada (*see also* New Brunswick; Nova Scotia; Prince Edward Island; *also* localities and bodies of water)
B 175 (economic study of oyster industry)

Markert, John Richard
J 28(12): 1853 (proteins in salmon eggs)
S 1521 (egg proteins of Pac. salmon)
1584 (soluble fractions of Pac. salmon eggs)

Marketing
B 175 (re economic study of Maritime Provinces oyster industry)

Marking methods, returns, and interpretation (*see also* Migration; Tagging)
J 28(3): 351 (Miramichi R., N.B., salmon to ascertain relative utilization rates by angling vs. Maritime commercial fisheries)
S 1581 (harp seal)
A 184 (harp seal)

Marlin, blue (*Makaira nigricans*)
T 272 (halogenated hydrocarbons residues in)

Marlin, striped (*Tetrapturus* (*Makaira*) *audax*)
J 28(7): 947 (blood pathway effects on blood-pressure drop in gills)

Marlin-spike (*Nezumia bairdi*)
T 261 (bibliography for Gulf of St. Lawrence)

Marshall, Kenneth Eric
T 151 (bibliography of coregonid fishes)
176 (bibliography of lake trout 1929–69)
209 (filing bibliographic references)

Marshall, Nelson
J 28(5): 769 (simple reliable method for assaying ^{14}C-labelled benthic microflora)

Mascaluk, Danny Mitchell
T 254 (phosphorus levels in Nfld. water)

Mason, John Christopher
S 1465 (copulatory behaviour of crayfish)
1468 (egg-laying in N American crayfish)
1486 (crayfish maternal–offspring behaviour)

Masset, Queen Charlotte Islands, B.C.
T 232 (razor clam breeding & growth)

Mathematical table
A 189 (exponentials (e^{-3} to e^{3}))

Mathematical treatment of data (*see also* Computer programming; Models, mathematical)
J 28(2): 225 (canonical multiple variant analysis of periphyton chemical composition)
(3): 369 (canonical multiple discrimination analysis of X-ray fluorescence spectroscopy for salmonids elemental chemical composition)
(7): 1035 (quick analysis of digital echo fish count sequences)
(9): 1275, 1293 (estimating fish abundance by voltage-integrating fish echo sounder)
(10): 1666 (Derzhavin's population analysis statistical method)
T 200 (extension of J 28(3) reference above)
212 (computer programming for multiple discrimination analysis of X-ray spectrographic data)
244 (multivariate analysis for fisheries biology)
248 (planktonic herbivores grazing re productivity studies)
264 (fluid mechanics of netting & low-solidity screens)
S 1494 (behaviour of growth & mortality estimates based on age–length keys)
1500 (re physics of bubble formation from decomposition of marine sediments)
1582 (Derzhavin's method)
1583 (comparison of 2 reproduction curves)
A 189 (assessment methods for freshwater fish production)

Mathias, Jack Anthony
J 28(5): 711 (Marion L. amphipod energetics)

Mating (*see also* Reproduction)
J 28(8): 1198 (supernumerary copulatory organs in *Dugesia tigrina* turbellarian)
S 1465 (*Pacifastacus trowbridgii* crayfish copulatory behaviour)
1555 (claw-shuddering behaviour of green shore crab to escape male–male attempted mating)

Matter, particulate (*see also* Productivity, primary)
J 28(2): 277 (carbon content, in sediments of 16 small NW Ont. lakes)
(2): 295 (carbon content of sediments re differences & similarities among small NW Ont. lakes)
(6): 911 (carbon & nitrogen: ratios, also seasonal & depth distributions, Chesapeake Bay, Md.)
(11): 1783 (^{65}Zn vs. Zn distribution in experimental marine ecosystem)
S 1485 (importance & general implications of organic, re plankton feed, particularly of filter-feeding copepods)
1503 (occurrence & formation of, in sea water)
1504 (continuous nephelometric measurement of seawater turbidity)

1537 (comparison of grade scales; proposed universal grade scale)
A 211 (size, re feed availability to different trophic levels in marine feed chain)

Maturity; Maturation
J 28(3): 417 (Pacific ocean perch)
(4): 477, 485 (effects of hormones & cortisol on gonadectomized adult sockeye salmon)
(4): 553 (spring vs. autumn spawning, SW Nfld. herring)
(7): 1051 (white seaperch, Tomales Bay, Calif.)
(9): 1309 (white whale, Cumberland Sound, Baffin Is., N.W.T.)
(10): 1621 (northern rockfish)
T 250 (computer programming fish maturity data)
A 214 (delaying or accelerating sexual, by hormones, to allow greater growth in fish farming, or to hasten cross-breeding tests)

Mauck, Wilbur Leon
J 28(7): 957 (northern pike predation)

Maxwell, James Rankin
S 1528 (geological fate of chlorophyll)

May, Arthur William
J 28(8): 1199 (salmon specimens from Davis Strait and Labrador Sea)
T 270 (digest of Canadian Atl. salmon catch statistics)
A 192 (marine fisheries for Atl. salmon)
195 (Labrador fisheries)
202 (salmon exploited at sea)
205 (problems relative to W Greenland salmon)

Mayflies (Ephemeroptera) (*see also* Insects, aquatic)
J 28(1): 35 (differences upstream & downstream of a dammed Ont. lake)
(5): 705 (biological magnification & degradation of insecticides by)
(6): 849 (samplings from shallow stream beds)
T 258 (toxicity tests of trisodium nitrilotriacetate detergent on, re pollution)
S 1532, 1533 (of a high Colorado mountain creek)

McAllister, Carey Douglas
T 248 (continuous grazing by planktonic herbivores)
S 1513 (marine production of zooplankton and phytoplankton)

McArn, Glynn Edward
J 28(9): 1241 (flounder skin tumors)

McBride, John Raymond
J 28(4): 477 (gonodal hormones effects on sockeye organs)
(4): 485 (effects of hormones on sockeye)

McCarraher, Donald Bruce
J 28(11): 1811 (survival of fish in alkaline eutrophic waters)

McCart, Peter
J 28(1): 115 (meristic differences in *Salvelinus alpinus*)
(5): 749 (variation in scale counts of arctic grayling)

McCauley, Robert William
J 28(11): 1801 (temperature selection of trout)

McCormick, J. Howard
J 28(6): 924 (temperature requirements for larval ciscos)

McCosker, John Edward
J 28(11): 1809 (lymphocystis disease in Pac. fish)

McCrary, Jerry Alden
J 28(1): 98 (differentiating between some female Pandalidae)

McDermott, Lawrence Alfred
J 28(9): 1350 (infectious pancreatic necrosis of salmonids)

McKim, James Montgomery
J 28(5): 655 (trout re toxicity of copper)

McKone, Warren Douglas
J 28(1): 110 (salmon evacuated from mountain whitefish stomach)

McLain, Douglas R.
J 28(1): 102 (bathythermograph transect data plotting)

McSheffrey, Hugh Michael
J 28(10): 1583 (X-ray spectrometry)

Meal, fish (*see* Crabmeal; Fish protein concentrate; Fishmeal; Shrimpmeal)

Medaka (*Oryzias latipes*)
J 28(9): 1235 (vertebral count re egg size)

Medcof, John Carl
B 177 (E Canada paralytic shellfish poisoning)
A 221 (20-million-year-old geological "catch")

Melanin
J 28(11): 1789 (distribution in butter clam re retention of paralytic shellfish toxin)

Melanogrammus aeglefinus (*see* Haddock)

Melanostigma atlanticum (*see* Pout, Atlantic soft)

Melosira
J 28(2): 265 (dominant diatoms in many small NW Ont. lakes)

Melville, Joanne Megan
J 28(11): 1817 (phosphatase activity in *Clostridium botulinum* spores & cells)

Menhaden, Atlantic (*Brevoortia tyrannus*)
J 28(3): 461 (range extension some 100 miles NE to Northumberland Strait)
T 261 (bibliography for Gulf of St. Lawrence)

Menidia menidia (*see* Silverside, Atlantic)

Méranger, Jean Charles
J 28(6): 843 (zinc retention in young rats fed increasing levels of high-zinc oysters)

Mercenaria mercenaria (*see* Quahaug, northern)

Mercer, Malcolm Clarence
T 199 (*A. T. Cameron* otter-trawl Atl. cruise)
S 1544(F) (northern limit of a squid)
1546 (cephalopod resources and fisheries)

Mercury derivatives
J 28(5): 786 (in dressed Canadian fishes from industrial area fishes)
(9): 1285 (methylmercury in freshwater & marine fishes, N.B., Bay of Fundy, & N.S. Banks; also in rain & snow)
(11): 1807 (sulphide: mobilization from aquatic sediments into fish)
S 1534 (assay procedure for fish by flameless atomic absorption spectrophotometry)
A 178 (details of procedure in S 1534 above)
200 (sources & effects of contamination in Canadian fishes)
201 (in Great Lakes fishes used as human food)

Meristic characteristics (*see also* Morphology; Speciation; Species, new; *also* Length; Size; Weight; *also* names of organisms)
J 28(1): 115 (anadromous vs. freshwater-resident arctic char)
(3): 427 (tube-snouts re sticklebacks osteology & phylogeny)
(4): 465 (lake char intraspecific variations & postglacial distribution)
(4): 553 (differences between spring- & autumn-spawning SW Nfld. herring)
(7): 987 (re systematics & evolution of western N America *Salmo* species & subspecies)
(7): 1009 (re discreteness of Gulf of St. Lawrence seasonal herring stocks)
(10): 1621 (northern rockfish)
T 160 (of 4 *Lepidion* morid fish species)
192 (greenland turbot)
237 (mud dab)
A 193 (Atl. & Pac. capelin)

Merluccius bilinearis (*see* Hake, silver)
productus (*see* Hake, Pacific)

Meromyxis (*see also* Limnology)
J 28(2): 265 (in 2 small NW Ont. lakes indicated by diatoms, ratio in sediments)

Mesh size (*see* Nets)

Mesocyclops (*see* Copepoda)

Mesodesma arctatum (*see* Clam, arctic wedge)

Mesodinium (ciliates) (*see also Cyclotrichium*)
J 28(3): 391 (*M. rubrum* "incomplete symbionts"; ultrastructure; taxonomy; key to *M. rubrum*, *M. acarus*, & *M. pulex*)

Mesotrophy
J 28(2): 265 (of lakes indicated by diatom species in sediments)

Messieh, Shoukry Naseef
J 28(7): 1009 (Atl. herring populations)
S 1464 (use of otoliths for aging herring)
1495 (immature Bay of Fundy herring)

Metabolism (*see also* Activity; Bioenergetics; Stress; *also* names of metabolic functions)
J 28(3): 409 (sockeye salmon feed intake)
(3): 449 (bluegill sunfish protein consumption & nitrogen excretion)
(4): 587 (factors influencing active & standard, of wild vs. hatchery rainbow trout)
(6): 801, 809, 815 (fish growth efficiency re rations & activity)
(10): 1635 (of young sockeye salmon re nature of diet)
(11): 1715 (benthos macroinvertebrates, L. Ontario bays)
(12): 1899 (stresses caused by formalin disinfection of young salmonids)
S 1497, 1498 (of putrescine by mycobacteria isolated from fish)
1590 : 534 (of fishes re environmental temperature acclimation: review)
A 197 (& biological production in freshwater fishes: review)
212 (energy cost of living, for fish: review)
222 (pollutants effects on Atl. salmon & brook trout)
232 (effects of radioactive pollutants in marine environment)

Metamorphism (*see* Development; *also* names of organisms)

Metavermilia (serpulid Polychaeta)
J 28(10): 1373 (revision of genus; 3 new species: *M. annobonensis*, *M. taenia*, *M. nates*; new form of parasite on gills of *M. nates*)

Meteorology (*see* Climate; Precipitation)

Methodology
T 249 (detecting & measuring marine oil adulteration of margarine & cooking fats)

Metridium dianthus (*see* Sea anemones)

Metroka, Craig Elliot
J 28(8): 1208 (killifish "hemagglutinogens")

Mettrick, David Francis
J 28(1): 7 (chemical composition of *Dugesia tigrina*)
(8): 1198 (abnormal sexual organs in fish)

Mice
B 177 (re paralytic shellfish toxicity assaying)

Michalik, Paula Annette
J 28(12): 1912 (fuel oil concentration in Chedabucto Bay)

Michigan, Lake (*see also* Great Lakes)
J 28(4): 616 (size of giant brook lampreys re average adult size)

Micrococcus (*see* Bacteria)

Microgadus proximus (*see* Tomcod, Pacific)
tomcod (*see* Tomcod, Atlantic)

Micropterus dolomieui (*see* Bass, smallmouth)
salmoides (*see* Bass, largemouth)

Microstomus pacificus (*see* Sole, Dover)

Midshipman, northern (*see* Midshipman, plainfin)

Midshipman, plainfin (*Porichthys notatus*) (northern midshipman)
T 257 (taken in 1970 B.C. trawl fishery)

Migration (*see also* Behaviour; Distribution; Homing; Marking; Spawning; Tagging; Tracking)
J 28(1): 49 (salamanders in Marion L., B.C.)
(3): 443 (computer programming for G. M. Jolly's stochastic model for capture–recapture)
(4): 573 (enumerating kokanee fry in streams)
(6): 919 (temperature & light effects on prespawning brook sticklebacks)
(8): 1133 (adult & juvenile walleye between L. Huron & L. Erie)
(9): 1345 (of carp through brackish B.C. coastal waters)
(9): 1319 (polarized light possibly aids yearling sockeye salmon seaward)
T 204 (male queen crabs, Gaspe region of Gulf of St. Lawrence)
S 1581 (harp seal)
A 184 (harp seal)
212 (energy requirements for fish when migrating: review)

Miles, Harry McCauley
J 28(5): 625 (handling & anesthetization effects on brook trout)
(5): 635 (brook trout variations re surgery)

Miller, Douglas Colenso
T 213 (B.C. offshore herring survey, 1969–70)

Miller, Robert Joseph
J 28(11): 1733 (productivity of seaweed–lobster communities)

Millikan, Alan Eugene
J 28(9): 1275 (estimation of hake population by echo integrator)

Milt (*see* Sperm; Testes)

Mineral constituents of natural waters (*see* names of lakes, names of chemical elements; *also* Composition, chemical; Limnology; Oceanography; Waters, natural)

Mineral content; Ash (*see* Composition, chemical)

Mineralogy (*see also* names of chemical elements)
J 28(2): 139, 277 (re limnology of many small NW Ont. lakes)

Mining effluents (*see* Copper; Pollution; Zinc)

Minkley, Bernard George
T 211 (Ocean Station P oceanographic observations)

Minnow, bluntnose (*Pimephales notatus*)
J 28(1): 45 (populations upstream & downstream of a dammed Ont. lake)

Minnow, fathead (*Pimephales promelas*)
J 28(7): 957 (vulnerability to northern pike predation)
(8): 1107 (mathematical model of effects of pollutant superimposed mortality on populations)
(8): 1119 (chronic effects of low dissolved oxygen concentrations)
(11): 1811 (alkali tolerance in eutrophic Nebraska lakes & ponds)

Minnow, sheepshead (*Cyprinodon variegatus*)
J 28(9): 1225 (cadmium toxicity tests)

Miramichi and Miramichi River, N.B.
J 28(1): 59 (DDT residues in marine fishes & shellfishes)

(3): 351 (relative utilization rates of Atl. salmon by local sport fishery vs. Maritime commercial fisheries)
T 202 (diatoms, and their use as indicators of heavy metal pollution)
226 (1969 fish mortalities in NW branch)
S 1553 (mining effluent effect on vascular plants of NW)

Mitchell, Edward Dick, Jr.
S 1574 (fin whale nasal structure)
1587 (pleistocene paleoecology and biostratigraphy, Santa Barbara Is., Calif.)

Models, mathematical (*see also* Mathematical treatment of data)
J 28(3): 443 (computer programming of G. M. Jolly's capture–recapture stochastic model)
(6): 801, 809, 815 (fish growth efficiency from rations)
(7): 971 (empirical, for *Sagitta elegans* chaetognath, St. Margaret's Bay, N.S.)
(8): 1107 (for effects of pollutant superimposed mortality in fathead minnow populations)
(8): 1211 (advantages & limitations re fishery catch & effort)
(10): 1573 (production–biomass ratio re animal cohorts & populations)
(10): 1493 (re simulation of Adams R. sockeye salmon abundance fluctuations)
(10): 1503 (pink & chum salmon fry size re predation by coho salmon)
T 248 (re nocturnal vs. continuous grazing by planktonic herbivores re marine productivity studies)
S 1513 (similar to T 248 above)

Modiolus dimissus (*see* Mussel, ribbed)
modiolus (*see* Mussel, red)

Mohamed, Mohideen Peer
J 28(9): 1342 (technique for measurement of carbon dioxide in fish)

Moisture content (*see* Composition, chemical)

Mola mola (*see* Sunfish, ocean)

Mollusca (*see also* subclassifications and names of species)
J 28(1): 35 (differences upstream & downstream of a dammed Ont. lake)
(6): 849 (samplings from shallow stream bed)
(6): 928 (in feed of tidepool & fluffy sculpins)
S 1470 (distributional checklist of B.C. marine, based on surveys since 1950)
1587 (fossil, re Pleistocene paleoecology of Santa Barbara Is., Calif.)

Molybdenum derivatives
S 1529 (distribution in L. Ontario)

Monkfish (*see* Goosefish)

Monochrysis lutheri (*see* Chrysophyceae)

Monodon monoceros (*see* Narwhal)

Monogenea (*see* Flukes)

Moon shell (*see* Clam drill, greater)

Moonlight (*see* Light, reactions to)

Moose, Paul Henry
J 28(9): 1293 (abundance estimate variance)

Moose Lake, Man.
J 28(5): 786 (heavy-metal concentrations in dressed lake whitefish & northern pike)

Moravec, F.
J 28(10): 1645 (N and Central American species of *Rhabdochona*)

Moridae (*see Lepidion*)

Morone americanus (*see* Perch, white)
chrysops (*see* Bass, white)
saxatilis (*see* Bass, striped)

Morphogenesis (*see also* Morphology)
S 1589 (*Dinoasteromonas* flagellates)

Morphology; Morphometry (biological) (*see also* Cytology; Histology; Length; Meristic characteristics; Size; Species, new; *also* names of organisms, organs, & tissues)
J 28(1): 23 (re taxonomic status of adult male *Calanus finmarchicus* & *C. glacialis*)
(1): 31 (cestode & trematodes in N Atl. swordfish)
(1): 73 (thermal springs dipteran herbivore *Hedriodiscus truquii*)
(1): 98 (sternal spines re female shrimps spawning history)
(3): 323 (*Lepeophtheirus* caligid copepod species parasitic to ocean sunfish)
(3): 427 (osteology re tube-snouts & sticklebacks phylogeny)
(4): 465 (lake char re intraspecific variations & postglacial distribution)
(4): 517 (*Vibrio anguillarum* bacterium)
(4): 543 (Canadian freshwater leeches: in key)
(5): 767 (new trematode species, *Labrifer balli*)
(5): 771 (rainbow trout morphometry, L. Superior)
(8): 1143 (of parasitic copepods locomotory parts)
(10): 1373, 1437, 1393, 1483, 1455, 1429, 1469, 1407, 1445 (various current and new polychaete species)
(10): 1527 (3 new hermit crab species, B.C.)
(10): 1563 (2 new *Holobomolochus* parasitic copepod species)

(10): 1621 (northern rockfish)
(10): 1615 (new caridean shrimp species, *Eualus berkeleyorum*)
(10): 1645 (7 *Rhabdochona* parasitic nematodes, including a new species)
(11): 1796 (two unusual Pac. gonatid squids of uncertain genus)
T 160 (of 4 *Lepidion* morid fish species)
S 1483 (variation in *Lecithophyllum botryophorum* trematode)
1488 (new genus & species of dinoflagellates from Canadian arctic lakes)
1496 (new genus & species of copepod from S India)
1499 (*Caligus rapax* syntypes re taxonomy)
1501 (*Haemobaphes intermedius* & *H. diceraus* parasitic copepods)
1533 (chironomids of a high mountain brook, Colorado)
1536 (deformed chironomids larvae)
1566 (new parasitic copepod species *Lernanthropus togatus*)
1568 (Eudactylinidae & Pseuocycnidae parasitic Copepoda)
1588 (*Harnischia* chironomids)
1589 (*Dinoasteromonas* flagellates, re discoasters)

Morphometry (biological) (*see* Morphology)

Morphometry (physical) (*see also* Geology; Glaciation; Limnology)
J 28(2): 139 (of 16 small NW Ont. lakes)
(2): 295 (re hypothesis to explain differences & similarities among small NW Ont. lakes)

Morrison, George Edwin
J 28(3): 379 (hardshell clam oxygen requirements)
(12): 1907 (respiration in flounder)

Morse, Norman Harding
B 175 (economic study of Maritime Provinces oyster fishery)

Mortality (*see also* Disease; Lethal limits; Pollution; Predation; Survival; Toxicants)
J 28(1): 65 (L. Superior lake trout populations re lamprey invasion)
(5): 745 (chinook & coho salmon sperm & eggs re fertilization by frozen preserved sperm)
(5): 755 (harbour seal pups, Sable Is., N.S.)
(7): 1057 (larval & juvenile fish in warm discharge canal of nuclear power plant)
(8): 1107 (mathematical model of pollutant superimposed mortality in fathead minnow populations)
(10): 1666 (re population biostatistical analysis)
(10): 1573 (re animal production–biomass ratio)
(10): 1545 (Pac. herring eggs & early larvae, re temperatures & salinities)
(10): 1511 (of hatching Pac. salmon eggs, re bacterial flora associated with egg surfaces)
(12): 1883 (winter kill of yellow perch & northern pike in Manitoulin Is. lakes (L. Huron))
T 226 (mass, of fish in NW Miramichi R., N.B., 1969)
243 (tank-cultured sablefish)
245 (mountain whitefish & rainbow trout, from uncertain causes, Kootenay L. & Lardeau R., B.C.; multispecies, from uncertain cause, tidal Nitinat L., B.C.)
248 (phytoplankton, from zooplankton grazing, re marine productivity)
S 1494 (behaviour of growth & mortality estimates based on age–length keys)
1513 (phytoplankton, from zooplankton grazing, re marine productivity)
1584 (herring, from coke-oven intermediate oil pollution in N Sydney Harbour, N.S.)

Mosquito (*Culex pipiens*)
J 28(5): 705 (biological magnification & degradation of insecticides by)

Mouse (*see* Mice)

Mouth (*see also* Jaw)
J 28(10): 1433 (role in terebellid polychaete tube building)

Movement (*see* Behaviour; Currents; Locomotion; Migration; Swimming; etc.)

Moxostoma macrolepidotum (*see* Redhorse, shorthead)

Mud (*see* Sediments)

Muir, Barry Sinclair
J 28(7): 947 (blood pathway and pressure drop in fish gills)

Multivariate analysis (*see also* Computer programming; Mathematical treatment of data)
J 28(3): 369 (of X-ray spectroanalysis of sockeye salmon from different regions)
T 200, 212 (of radioisotope X-ray fluorescence spectrometric data)
S 1510 (re applying bioassay results to pollutants toxicity towards fish)
1580 (shallow-water marine benthos, P.E.I.)

Mummichog (*Fundulus heteroclitus*)
J 28(7): 999 (schooling vs. aggregation spacing & density)
(8): 1208 ("hemagglutinogens")
(9): 1225 (re cadmium poisoning)
T 255 (yellow phosphorus toxicity tests)
261 (bibliography for Gulf of St. Lawrence)

Mundie, John Harold
J 28(6): 849 (sampling benthos & substrate materials in shallow streams)

Munidopsis (crabs)
J 28(10): 1527 (*M. quadrata* range extension off B.C.)

Murray, Derek A. J.
J 28(7): 1043 (NTA determination in inland waters)

Muscle (*see also* Fillets; Flesh; Myosin; Protein; Quality of fishery products)
J 28(1): 1 (dimethylamine & other amine formation in stored frozen light vs. dark muscle of various Atl. coast fishes)
(1): 59 (DDT residues in N.B. & P.E.I. fishes & shellfishes)
(6): 869 (octopine formation in sea scallop, as possible freshness index)
(7): 1005 (multiple malate dehydrogenase isozymes of walleye skeletal, re genetics)
(7): 1053 (genic polymorphism of tetrazolium oxidase in bluefin tuna)
(8): 1191 (fatty & amino acids of Dungeness crab skeletal)
(8): 1203 (field technique for obtaining small samples from living fish)
(9): 1325 (postmortem changes in glycogen phosphorylase activity in sucker & pike)
(11): 1745 (myogens & lactate dehydrogenase of suckers)
B 177 (paralytic shellfish toxin in E Canada shellfishes adductor)
T 256 (scallop meat size, Georges Bank commercial fishery)
S 1459, 1506 (sterols of sea scallop)
1509 (accelerated denaturation of rabbit & trout myosin in frozen solution
1527 (sterols of crustacean)

Muskellunge (*Esox masquinongy*) (*E. maskinongy*; Great Lakes muskellunge)
T 261 (bibliography for Gulf of St. Lawrence)
A 201 (mercury contamination in Great Lakes)

Muskellunge, Great Lakes (*see* Muskellunge)

Mussel, black (*see* Mussel, blue)

Mussel, blue (*Mytilis edulis*) (black mussel)
J 28(1): 59 (DDT residues in N.B. & P.E.I.)
(5): 793 (yellow phosphorus concentration in body, N.S.)
(9): 1225 (cadmium toxicity tests)
B 177 (re paralytic shellfish poisoning, E Canada)
S 1569 (determination of residual fuel oil contamination in)

Mussel, horse (*see* Mussel, red)

Mussel, red (*Volsella* (*Modiolus*) *modiolus*) (horse mussel)
B 177 (re paralytic shellfish poisoning, E Canada)

Mussel, ribbed (*Modiolus demissus*)
J 28(4): 527 (upper lethal temperatures re osmotic stress)

Mya arenaria (*see* Clam, softshell (Atlantic))

Myctophidae (*see* Lanternfishes; *also* names of species)

Myctophum punctatum (*see* Lanternfish, spotted)

Mylocheilus caurinus (*see* Peamouth)

Myogens (*see also* Muscle; Myosin)
J 28(11): 1745 (of dwarf & large white suckers & of longnose sucker)

Myosin (*see also* Muscle; Myogens)
S 1509 (accelerated denaturation of rabbit & trout, in frozen solution)
1561 (sulphydryl content of rabbit & rainbow trout, re protein stability)

Myoxocephalus aenaeus (*see* Grubby)
octodecemspinosus (*see* Sculpin, longhorn)
polyacanthocephalus (*see* Sculpin, great)
scorpioides (*see* Sculpin, arctic)
scorpius (*see* Sculpin, shorthorn)

Mysids
J 28(2): 257 (*Mysis relicta* in zoobenthos of 15 small NW Ont. lakes)

Mysis relicta (*see* Mysids)

Mytilus edulis (*see* Mussel, blue)

Myxine glutinosa (*see* Hagfish, Atlantic)

N

Nakai, Shurye
S 1531 (casein & polyethylenimine)

Nakamura, Royden
J 28(6): 928 (food of tide-pool Cottidae)

Nakatani, Roy Eiji
J 28(9): 1253 (*Chondrococcus columnaris* disease)
(11): 1739 (disease susceptibility of young trout and salmon)

Narayanan, Memana
J 28(9): 1342 (technique for measurement of carbon dioxide in fish)

Narver, David Wells
CNG 91 (Vancouver Is. steelhead trout age & size)

Narwhal (*Monodon monoceros*)
MSP 13(F) (actual & potential Canadian Arctic fishery)
A 231 (actual & potential Canadian Arctic fishery)

Nash, Frank William
T 251 (length–girth relationships for Pac. perch)

Nasopalatine canals
S 1574 (oral remnants of, in fin whales)

Nassarius obsoletus (*see* Snail, eastern mud)

National Parks (*see* Banff National Park; Jasper National Park; Waterton Lakes National Park; Yoho National Park)

Neal, Wanda Eloise
J 28(1): 1 (DMA in muscle of gadoid fish)

Nebraska
J 28(11): 1811 (freshwater fishes tolerance to alkalinity in eutrophic lakes & ponds)

Necrosis (*see* Disease; Virus)

Neish, Iain Charles
J 28(1): 49 (salamander populations in Marion L., B.C.)

Nelson, Joseph Schieser
J 28(3): 427 (comparison of the Aulorhynchidae & Gasterosteidae)

Nematocysts
J 28(10): 1677 (types in a sea anemone)

Nematoda (roundworms)
J 28(10): 1385 (various Polychaeta as intermediate hosts of)
(10): 1645 (N & Central America distribution of *Rhabdochona*, including a new species *R. canadensis*; descriptions of 5 other species & key to genus)
T 160 (3 species found in *Lepidion eques* morid fish)
S 1487 (diseases & other effects of parasitization on fishes; review)
1532 (Tylenchidae of a high Colorado mountain creek)
1565 (instrument for removing cephalic sections)
A 181 (*Anisakis* as parasitic indicator of geographical origin of Atl. salmon stocks)
219 (*Anisakis* incidence variations in Atl. herring from different Canadian areas)
224 (parasitic to N American, USSR, & European coregonid fishes)

Neoamphitrite robusta (terebellid polychaete)
J 28(10): 1433 (tube-building re feeding)

Neptune, ten-ridged (*see* Whelk, ten-banded)

Neptunea decemcostata (*see* Whelk, ten-banded)

Nereis (*see* Polychaeta)
virens (*see* Sandworm)

Nervous system
S 1550 (re Atl. sea raven gill proprioceptors reflexes)

Nets (*see also* Plankton; Trawling; Sampling)
J 28(6): 821 (gillnet selectivity re Skeena R. sockeye & pink salmon fisheries)
(8): 1167 (American shad net avoidance behaviour)
T 264 (fluid mechanics of nets, netting, & low-solidity screens)
S 1493 (assessments of effects of increasing mesh size of Atl. cod trawls)

New Brunswick (*see also* Fundy, Bay of; Miramichi River; St. Lawrence, Gulf of; *also* localities and bodies of water)
J 28(1): 59 (DDT residues in marine fishes & shellfishes)
(9): 1285 (methylmercury in freshwater & marine fishes)
B 175 (economic study of Maritime Provinces oyster industry)
T 270 (Atl. salmon catches, 1947–69)
S 1552 (DDT residues in young salmon re forest spraying)
A 207 (herring fishery, 1963–69, & biology)
208 (Bay of Fundy herring vertebral numbers, & origin of "sardine" herring)

Newfoundland (*see also* Labrador)
J 28(4): 553 (meristic differences between spring & autumn spawning herring from SW)
CJG 18: 1 (recent herring fishery developments); 20 (herring tagging results in SW coastal waters); 25 (herring investigations in NE coastal waters & Labrador)
T 233 (Long Harbour bottom deposits content of elemental phosphorus & fluorides)
270 (Atl. salmon catches, 1956–69)
S 1542 (temperatures & salinities in E waters)
A 181 (research summary of transplant of B.C. pink salmon to)
185 (capelin as a latent resource)
192, 193, 194 (capelin fishery)
194 (general fisheries)
223 (combating elemental phosphorus pollution, Long Harbour)

Newt (*Taricha granulosa*)
J 28(1): 49 (populations in Marion L., B.C.)

Nezumia bairdi (*see* Marlin-spike)

Nichols, Frederic Hone
J 28(10): 1491 (new benthic polychaetes)

Nicholson, Harold Frederick
S 1529 (trace elements and chlorophyll in L. Ontario)

Nickel derivatives
J 28(2): 277 (in sediments of 4 small NW Ont. lakes)
(5): 786 (in dressed Canadian fishes from industrial area lakes)
S 1529 (distribution in L. Ontario)

Nigrelli, Ross F.
J 28(8): 1208 (killifish "hemagglutinogens")
(11): 1809 (lymphocystis disease in Pac. fish)

Nitinat Lake, Vancouver Island, B.C. (tidal)
T 245 : 12 (multispecies mortality from probable sudden overturn of waters)

Nitrate (for general data re content in natural waters, *see* Nutrients, aquatic; *see also* Limnology; Oceanography)
J 28(2): 171, 203 (in waters of several small NW Ont. lakes)
(2): 203 (effect on photosynthesis when added to samples of water from small NW Ont. lakes)
(11): 1763 (eutrophication of small NW Ont. lake upon addition of)
T 265 (in sea waters & ice, Frobisher Bay, Baffin Is., N.W.T.)
S 1467 (automated measurement of, in sea water)
A 216 (re Great Lakes eutrophication)

Nitrilotriacetate, trisodium (detergent to replace phosphates)
J 28(7): 1043 (determination in inland waters)
T 258 (toxicity tests on aquatic invertebrates & amphibians, re detergent pollution)
S 1536 (as possible cause of deformed chironomids larvae in lakes)

Nitrite (for general data re content in natural waters *see* Nutrients, aquatic; *see also* Limnology; Oceanography)
J 28(2): 171 (in waters of several small NW Ont. lakes)

Nitrogen derivatives (*see also* Amines; Ammonia; Nitrate; Nitrite; Proteins; *also* other types of nitrogen compounds)
J 28(1): 7 (seasonal changes in lipid, protein, & other nitrogen of freshwater triclad flatworm)
(2): 171 (total dissolved, in waters of many small NW Ont. lakes)
(2): 215 (content of periphyton in 4 small NW Ont. lakes)
(2): 277 (content of sediments in 16 small NW Ont. lakes)
(2): 295 (re similarities & differences in small NW Ont. lakes)
(3): 449 (re protein consumption of bluegill sunfish)
(6): 911 (particulate, re carbon: nitrogen relations in Chesapeake Bay Md.)

Nocomis biguttatus (*see* Chub, hornyhead)
micropogon (*see* Chub, river)

Nomenclature (*see also* Taxonomy)
J 28(3): 323 (*Lepeophtheirus* vs. *Dentigryps* caligid parasitic copepods)
(7): 987 (*Salmo* species of Upper Kern R. Basin, Calif.)
S 1499 (misuse of name *Caligus rapax* (copepod) since 1850)
1588 (*Harnischia* chironomids)

Non-linear response surfaces
T 244 : 42 (re multivariate analysis)

North Boulder Creek, Colorado
S 1532 (distribution of invertebrates in, as high mountain brook with lakes)
1533 (chironomids & other invertebrates in)

Northcote, Thomas Gordon
J 28(9): 1259 (cutthroat and Dolly Varden segregation)

Northwest Territories (Canada) (*see also* Arctic)
A 231 (fish production & utilization for man & dogs)

Nota, Dirk Johannes Gregorius
S 1511 (European flints on N American coast)

Notacanthus nasus (*see* Eel, spiny)

Notemigonus chrysoleucas (*see* Shiner, golden)

Notoscopelus krøyeri (*see* Lanternfish, Krøyer's)

Notropis cornutus (*see* Shiner, common)
hudsonius (*see* Shiner, pottail)
spilopterus (*see* Shiner, spottail)

Nova Scotia (*see also* Bedford Harbour; Fundy, Bay of; Oceanography, Atlantic coast; St. Lawrence, Gulf of; St. Margaret's Bay; *also* other localities)
J 28(5): 755 (whelping seal colony observations, Sable Is.)
(9): 1285 (methylmercury in N.S. banks fishes)
B 175 (economic study of Maritime Provinces oyster industry)
T 252 (ecology & distribution of herring larvae along S coast; macrozooplankton biomass ecology on Scotian Shelf)
270 (Atl. salmon catches 1947–69)
A 207 (herring fishery, 1963–69, & biology)
208 (Bay of Fundy herring vertebral numbers)

Noven, Bengt
J 28(2): 245 (zooplankton distribution & abundance in 2 FRB Experimental Lakes, NW Ont.)

Nuclear power plant (*see also* Thermal power plants)
J 28(7): 1057 (mortality vs. survival of larval & juvenile fish in warm water of discharge canal)
A 232 (effluent as source of radioactivity in marine environment)

Nucleic acids (*see* Acids, nucleic; Nucleosides)

Nucleosides; Nucleotides (*see also* Acids, amino; Acids, nucleic; Enzymes)
J 28(6): 869 (re octopine formation in sea scallop muscle)
(10): 1603 (ribonucleotide reductase in sockeye salmon immature testes)
S 1508 (salmon testes deoxyribonuclease re internucleotide linkages)
1523 (lingcode muscle purine & pyrimidine nucleoside phosphorylases)
1525 (trout liver pyrimidine deoxynucleoside phosphorylase & deoxyribosyltransferase)
1560 (deoxyribonucleic acid polymerase from sockeye salmon testes)
A 226 (nucleoside cyclic phosphate diesterases)
227 (nucleotide phosphomonoesterases)

Nucleotides (*see* Nucleosides)

Nutrients, aquatic (*see also* Limnology; Oceanography; Productivity, primary)
J 28(2): 171, 203 (in waters of many small NW Ont. lakes)
(2): 203 (effects of various nutrients on photosynthesis when added to water samples from various small NW Ont. lakes)
(5): 790 (nitrogen, phosphorus, & iron enrichment influence on photosynthesis & assimilation ratios of N Pac. phytoplankton)
T 247 (Bedford Basin, N.S., re phytoplankton production, 1969–70)
265 (in Frobisher Bay waters & ice, N.W.T., re primary production)
S 1467 (automated measurement of seawater dissolved)
1482 (comparison of eutrophicated Bedford Basin vs. nearby St. Margaret's Bay, N.S.)
1485 (importance & general implications of organic matter in aquatic environments, particularly re filter-feeding copepods)
1538 (marine dissolved, re energy flow & species diversity in phytoplankton bloom)
A 216 (re Great Lakes eutrophication)
220 (program during C.S.S. *Hudson* oceanographic survey circumnavigating N & S America)

Nutrition value (*see also* Composition, chemical; Feed; Feedstuff; Production, primary; Rations)
J 28(10): 1635 (of zooplankton in young sockeye salmon diets)
T 248 (re planktonic herbivores grazing & production)

Nyman, Olof Lennart
S 1545 (electrophoretic analysis of hybrids)
1547 (ecological interaction of trout)

O

Obituary
J 28(4): 599 (John Douglas Hipwell Strickland)

Ocean (*see* Oceanography headings; *also* names of oceans)

Ocean Station P (*see* Oceanography, north Pacific Ocean)

Oceanography, arctic
T 265 (physical, nutrient, & primary production data, Frobisher Bay, Baffin Is.)
MSP 13(F) (summary of FRB investigations of Canadian)

Oceanography, Atlantic west coast (*see also* Hydrography; Oceanography, northwest Atlantic; Pollution)
T 219 (St. Margaret's Bay, N.S.)
247 (Bedford Basin, N.S., re phytoplankton production)
252 (temperatures, N.S. Shelf)
271 (Gulf of St. Lawrence circulation patterns & geopotential anomalies, June 1968 & Sept. 1969)
S 1482 (comparison with eutrophicated Bedford Basin, N.S.)
1542 (temperatures & salinities off E Nfld., 1969)

Oceanography, general (*see also* Pollution; Production, primary; Sea water; Sounding, echo)
J 28(1): 102 (plotting bathythermograph transect data on computer printer)
T 218 (effects of sea water on bacteria survival)
S 1467 (automated measurement of dissolved nutrients)
1472 (phenosafranin as improved indicator in chlorinity titrations)
1476 (implementation of Canadian ocean engineering, chemical oceanography, & geochemistry re pollution & climatology)
1512, 1515 (isopiestic measurements of ternary systems)
1539 (re capacity of estuaries to accept pollutants; use of dyes)
A 183 (re ocean resources management)
220 (C.S.S. *Hudson* circumnavigation of N & S America)

Abbreviations: J — *Journal.* B — *Bulletin.* AR — *Annual Report.* R — *Review. Circular Series*: CHN — Halifax; CNG — Nanaimo; CJG — St. John's. T — *Technical Reports.* MSP — *Miscellaneous Special Publications.* S — *Studies.* A — *Interpretive Articles.*

232 (radioactivity in the marine environment: extensive summary of book)

Oceanography, North Pacific Ocean (*see also* Oceanography, Pacific Coast)
T 211 (data from Ocean Weather Station P oceanographic program, 1969–70)
230, 240 (Ekman transport charts, 1969, 1970)
238, 239 (Ekman & other transport computations, 1970, 1969)
A 204 (re INPFC salmon & steelhead trout studies)

Oceanography, Northwest Atlantic (*see also* Hydrography; Oceanography, Atlantic coast)
T 199 (re otter-trawl survey, 1969)
A 223 (combating pollutants)

Oceanography, Pacific east coast (*see also* Oceanography, North Pacific Ocean; Pollution)
J 28(5): 727 (re petrale sole embryonic development)
(8): 1077 (physical oceanographic features of 32 Chilean fiord inlets & adjacent waters)
T 210 (during B.C. otter trawl surveys)
253 (Strait of Georgia temperatures & current velocities, 1968–70)

Octopine (arginine derivative)
J 28(6): 869 (in sea scallop muscle re freshness index)

Octopus (*Octopus apollyon*)
T 257 (taken in 1970 B.C. trawl fishery)

Octopuses
T 225 (associated with Bay of Fundy scallop beds)

Odense, Paul Holger
J 28(11): 1793 (effects of oil on cardiac functions of rats)
T 229 (effects of herring oil on organs of rats)

Odobenus rosmarus (*see* Walrus)

Odonata (*see also* Insects, aquatic)
J 28(5): 705 (biological magnification & degradation of insecticides by)
T 258 (toxicity tests of trisodium nitrilotriacetate detergent on, re pollution)

Odour and reactions to (*see also* Quality of fishery products)
J 28(4): 565 (olfactory epithelium electrical responses of Atl. salmon to various organic chemicals)
T 165(F) (muddy, in rainbow trout)
S 1574 (oral remnants of nasopalatine canals in fin whales)

O'Halloran, Mary Jane
S 1477 (Leydig cell homolog in testis of sexually mature Atl. salmon)
1478 (identification of interrenal tissue in American Atl. salmon)

Oils, fuel (as pollutant) (*see* Oils, petroleum)

Oils, petroleum (as pollutants)
J 28(9): 1327 (Copepoda tolerance to particulate oil, & its sedimentation via feces)
(12): 1912 (residues in Chedabucto Bay, N.S., 14 months after spill of)
T 217 (characterization, re tracing origin of spills affecting aquatic environment)
S 1476 (Canadian implementation of ocean engineering, chemical oceanography, & geochemistry re oil pollution)
1569 (determination of residual contamination of aquatic animals)
A 223 (combating, on Canadian Atl. coast)

Oils and fats (*see also* Acids, fatty; Glycerides; Lipids; Oils, petroleum)
J 28(4): 601 (fatty acids of sand lance oils & lipids)
(11): 1793 (see T 229 below)
T 216, 257 (landings for, from B.C. & U.S. Pac. coast commercial trawling, 1969, 1970)
220 (effects of storing sockeye salmon in ice vs. refrigerated sea water on free oil content of canned product)
229 (rat tests to see if feeding raw or partially hydrogenated Atl. herring oil causes heart or liver fat deposition)
249 (analysis methods for detecting & estimating marine oil adulteration of all-vegetable margarines & cooking fats)
272 (halogenated hydrocarbon residues in commercial Atl. fish oil)
S 1514 (Amazon R. dolphin jaw & blubber fats composition re echolocation ability)
1584 (coke-oven intermediate oil re herring mortality in N Sydney Harbour, N.S.)
1591 (pristane & other hydrocarbons in some freshwater & marine Canadian commercial fish oils)

Okanagan Valley lakes, B.C.
S 1536 (deformed chironomids larvae possibly caused by synthetic chemical pollutants)

Olfactory perception and response (*see* Odour)

Oligochaeta
J 28(3): 335 (tubificid, of Toronto Harbour, L. Ontario: types of sediment bacteria surviving ingestion by)
(6): 849 (samplings from shallow stream bed)
(11): 1683 (associations & species diversification in L. Ontario bays)
S 1532, 1533 (of a high Colorado mountain creek)
1543 (Georgian Bay, L. Ontario, & L. Erie; also key)

Oligocottus maculosus (*see* Sculpin, tidepool)
snyderi (*see* Sculpin, fluffy)

Oligotrophy (*see also* Eutrophication)
J 28(2): 265 (in several small NW Ont. lakes as

indicated by diatom species in sediments)
(11): 1683 (re benthic macroinvertebrates associations & species diversity in L. Ontario bays)

Olson, P. A.
J 28(11): 1739 (disease susceptibility of young trout and salmon)

Oncorhynchus gorbuscha (*see* Salmon, pink)
keta (*see* Salmon, chum)
kisutch (*see* Salmon, coho)
nerka (*see* Salmon, sockeye; Kokanee)
nerka (*kennerlyi*) (*see* Kokanee)
tshawytscha (*see* Salmon, chinook)
see also Salmon (Pacific, in general)

Ontario (*see also* Erie, Lake; Georgian Bay; Great Lakes; Huron, Lake; Ontario, Lake; Quinte, Bay of; St. Clair, Lake; Superior, Lake; *also* other localities and bodies of water)
J 28(2): entire issue (FRB Experimental Lakes Area program for biological productivity & eutrophication in many small lakes)

Ontario, Lake (*see also* Great Lakes)
J 28(5): 786 (heavy-metal concentrations in dressed lake whitefish)
(11): 1683 (benthic macroinvertebrates associations & species diversity in certain bays)
(11): 1699 (macroinvertebrate production in certain bays)
(11): 1715 (benthos community · metabolism in certain bays)
S 1529 (trace elements & chlorophyll *a* distribution)
1536 (occurrence of deformed chironomids larvae possibly caused by synthetic chemical pollutants)
1543 (Oligochaeta, Sphaeriidae, & Chironomidae)

Ophiodon elongatus (*see* Lingcod)

Ophiuroidea (*see* Starfishes)

Orcinus orca (*see* Whale, killer)

Orconectes virilis (*see* Crayfishes)

Ordination (*see also* Associations; Communities)
S 1580 (& classification of many shallow-water benthic species, P.E.I.)

Ornithology (*see* Birds; *also* names of species)

Orthopagurus (crabs)
J 28(10): 1527 (*O. minimus* range extension off B.C.)

Oryzias latipes (*see* Medaka)

Osmerus mordax (*see* Smelt, rainbow)

Osmoregulation (*see* Salinity, reactions to)

Osteology (*see also* Bone)
J 28(3): 427 (re phylogenetic implications in tubesnouts and sticklebacks)

Ostovar, Kurosh
J 28(5): 643 (gamma irradiation of whitefish *Salmonella*)
(5): 783 (effects of washing on keeping quality of freshwater fish)

Ostracoda (*see also* Crustacea)
J 28(6): 928 (in feed of fluffy & tidepool sculpins)
T 266 (*Philomedes globosa*, Frobisher Bay, Baffin Is., N.W.T.)
S 1587 (fossil, re Pleistocene paleoecology of Santa Barbara Is., Calif.)

Otoliths
J 28(10): 1621 (re aging northern rockfish)
T 231 (re aging arctic char)
S 1464 (critique of use for aging Gulf of St. Lawrence herring)

Ott, Alvin George
J 28(5): 745 (cryo-preserved sperm fertilize salmon eggs)
(12): 1915 (preservation of trout sperm)

Otter, sea (*see* Sea otter)

Otter trawl (*see* Trawling)

Otto, Robert George
J 28(3): 343 (pre-smolt coho survival & growth re salinity)

Ova (*see* Eggs)

Ovary (*see also* Eggs; Fecundity; Gonads; Hermaphroditism; Hormones; Maturity; Reproduction; Spawning)
J 28(4): 477, 485 (hormones effects on gonadectomized sockeye salmon)
(5): 793 (selective accumulation of yellow phosphorus from sea water, by lobster)
(7): 971 (length re body length of mature *Sagitta elegans* arrow worms, St. Margaret's Bay, N.S.)
(7): 1029 (fecundity of right vs. left, in Atl. capelin)
(8): 1191 (fatty acids & amino acids of Dungeness crab)

S 1535 (chinook salmon gonadotropin effect on growth & maturation of gonadectomized vs. normal guppy)
1557 (temperature & photoperiod effects on crayfish maturation of)

Oxygen, dissolved (for general data re natural waters *see* Limnology; Oceanography; *see also* Respiration)
J 28(2): 157, 257 (of many small NW Ont. lakes)
(2): 295 (re differences & similarities among small NW Ont. lakes)
(3): 379 (requirements for northern quahaug embryonic & larval development)
(6): 883 (effects on Pac. cod eggs development re geographical distribution)
(8): 1119 (chronic effects of low concentrations on fathead minnow)
(8): 1196 (digital recorder monitoring in fish tanks)
(9): 1303 (depletion effect on walleye photic behaviour)
(10): 1459 (concentration re polychaete settlement on test panels)
(11): 1815 (dispenser for simultaneous delivery of Winkler reagents)
(12): 1823 (handling & salinity effects on striped bass requirements)

Oyster, Atlantic (*Crassostrea virginica*)
J 28(1): 59 (DDT residues in N.B. & P.E.I.)
(6): 843 (biological activity of zinc in, determined by feeding to rats)
B 175 (economic study of Maritime Provinces fishery)
S 1572 (saturated & isoprenoid fatty acids distribution in lipids)
A 109(F) (eelgrass control on beds)
200 (mercury contamination)

Oyster, Pacific (*Crassostrea gigas*)
B 178 (raft culture in B.C.)

Oyster drill, Atlantic (*Urosalpinx cinerea*)
J 28(9): 1225 (cadmium toxicity tests)

P

Pachycerianthus (*see* Sea anemones)

Pacifastacus trowbridgi (*see* Crayfishes)

Pacific Ocean (*see also* Oceanography)
J 28(10): 1403 (amphipacific distribution of some 25 polychaete species)
T 230, 240 (N Pac. Ekman transport charts, 1969, 1970)
238, 239 (N Pac. Ekman & other transport calculations, 1970, 1969)
246 (bibliography of trawled fishes off Alaska, B.C., USA)
S 1466, 1467 (large-scale studies of primary production in northern)
A 204 (salmon & steelhead trout studies in northern)

Packaging
A 203 (advances in, for fishery products)

Pagophilus groenlandicus (*see* Seal, harp)

Paguristes (crabs)
J 28(10): 1527 (new records off B.C. for *P. tergidus* & *P. ulreyi*)

Pagurus (*see* Crabs, hermit)

Paintings
A 228 (of Greenland life & scenery: book review)

Palaemonetes kadiakensis (*see* Shrimp, glass)
vulgaris (*see* Shrimp, grass)

Paleolimnology (*see* Evolution; Geology; Glaciation)

Palinurus argus (*see* Lobster, spiny)

Pancreas (*see also* Hepatopancreas)
J 28(4): 485 (histological effects of hormones & cortisol on gonadectomized adult sockeye salmon)
(7): 1064 (vs. feces re presence of necrosis virus in brook trout)
(9): 1350 (infectious necrosis virus found in 2 Ont. brook trout hatcheries)
S 1462 (substrate specificity of pancreatic lipase)
1471 (pancreatic lipase colorimetric assay method)

Pandalid, benttail (*Pandalus goniurus*) (proposed name in B.C. for humpy shrimp of Alaska; *see* Shrimp, humpy)

Pandalid, bluespotted (*Pandalus stenolepis*) (proposed name in B.C. for this species)
T 241 : 38 (bibliography)

Pandalidea (*see also* Pandalid; Prawn; Shrimp)
T 241 (bibliography, with emphasis on economically important *Pandalus* species)

Pandalopsis dispar (*see* Shrimp, sidestripe)

Pandalus borealis (*see* Shrimp, pink)
danae (*see* Shrimp, coonstripe)
goniurus (*see* Shrimp, humpy; Pandalid, benttail)
hypsinotus (*see* Shrimp, humpback)
jordani (*see* Shrimp, smooth pink)
kessleri (*see* Prawns)
montagui (*see* Shrimp, striped pink)
platyceros (*see* Prawn)
stenolepis (*see* Pandalid, bluespotted)
species in general (*see* Pandalidae)

Paralepis coregonoides borealis (*see* Lancetfish, scaled)
rissoi krøyeri (*see* Barracudina, white)

Paralichthys californicus (*see* Halibut, California)

Paraliparis copei (*see* Seasnail, blacksnout)

Paralomis (crabs)
J 28(10): 1527 (*P. verrilli* first record off B.C.)

Paralytic shellfish poisoning
J 28(11): 1789 (melanin distribution in butter clam re retention of paralytic toxin)
B 177 (in E Canada: history; sources; symptoms; precautions; case histories)

Parapagurus (hermit crabs)
J 28(10): 1527 (*P. pilosimanus* range extension off B.C.)

Parapasiphaë (caridean shrimps)
J 28(10): 1615 (*P. sulcatifrons* new record, off B.C.)

Parasites; Parasitization (*see also* Disease)
J 28(1): 31 (cestode & trematodes in N Atl. swordfish)
(3): 323 (caligid *Lepeophtheirus* copepods from ocean sunfish)
(4): 616 (probable parasitism by giant type of American brook lamprey, vs. non-parasitism by ordinary type)
(5): 767 (*Labrifer balli*, new trematode species, from California pink seaperch)
(5): 771 (rainbow trout by lampreys, Batchawana Bay, L. Superior)
(6): 901 (habitat of 2 blood fluke species in N Pac. rockfishes re habitat of those fishes)
(8): 1143 (locomotory mechanisms of 2 copepods)
(10): 1373 (new form of parasite found on *Metavermilia nates* polychaete)
(10): 1527 (of hermit crabs)
(10): 1385 (various Polychaeta as intermediate hosts of helminth parasites)
(10): 1563 (2 new species, 1 new record, & several new hosts, of bomolochid copepods)
(10): 1615 (*Hemiarthrus abdominalis* isopod in new shrimp species)
(10): 1645 (*Rhabdochona* nematode species in N & Central America fishes, including a new species *R. canadensis*)
T 160 (of 4 *Lepidion* morid fish species)
246 (bibliography of, from N America Pac. coast trawled fishes)
250 (computer programming fish parasite data)
S 1483 (morphometric variation in *Lecithophyllum botryophorum* trematode in Atlantic argentine)
1487 (diseases & other effects of nematode parasitization of fishes: review)
1496 (new genus & species of copepod, from S India)
1501 (*Haemobaphes* copepods on Strait of Georgia sculpins)
1566 (new copepod species *Lernanthropus togatus* on gills of marine Kenyan fish *Gaterin*)
1567 (Crustacea as enemies of fishes, re diseases)
1568 (copepods on Australian fishes)
A 58(F) (fluke larvae cause of human dermatitis)
224 (world distribution of coregonid fishes & their parasites)

Parker, Robert Ray
J 28(10): 1503 (size selective predation)
(12): 1921 (herring predators on young salmon)
S 1499 (redescription of syntypes of *Caligus rapax*)

Parks (*see heading* National Parks)

Parophrys vetulus (*see* Sole, English)

Parr (*see* names of adult fishes, e.g., Salmon; Trout)

Parsons, Leon Scott
J 28(4): 553 (Atl. herring meristic characters)
CJG 18: 25 (NE Nfld. & Labrador herring investigations)

Parsons, Timothy Richard
J 28(4): 599 (obituary — J.D.H. Strickland)
S 1466 (primary production studies in N Pac. Ocean)
1485 (organic matter in aquatic environments)
1503 (small particles in sea water)
A 183 (bases of resource management; oceanography)
210 (review of book on marine chemistry)
211 (availability of food in marine food chain)

Particulate matter (*see* Matter, particulate)

Passamaquoddy Bay, N.B.
J 28(7): 935 (components of fish communities by seasons, abundance & temperature regime, re communities in warmer waters)

Patalas, Kazimierz
J 28(2): 231 (zooplankton communities in 45 FRB Experimental Lakes, NW Ont.)

Paterson, Colin Garth
J 28(3): 365 (simple corer vs. Ekman grab)

Pathogens (*see* Bacteria; Disease; Pathology; Viruses)

Pathology (*see also* Cytology; Disease; Histology; Parasites; Viruses)
J 28(1): 104 (rainbow trout skin lesions)
(3): 448 (lake trout subcutaneous fibroma)
(4): 517 (vibriosis of Pac. salmons)
(9): 1241 (skin tumours on Pac. flounders)

T 245 (re mass mortality from uncertain causes, of mountain whitefish & rainbow trout, Kootenay L., B.C.)
S 1487 (of nematode-parasitized fishes)

Patinopecten caurinus (*see* Scallop, weathervane)

Patten, Benjamin Gene
J 28(9): 1352 (increased predation by torrent sculpin)

Peamouth (*Mylocheilus caurinus*)
J 28(9): 1331 (W Washington distribution re zoogeography)

Pearcy, William Gordon
J 28(12): 1831 (distribution and abundance of Salpidae)

Peden, Alex. E.
J 28(6): 927 (range extension of B.C. masked greenling)
(9): 1347 (record of bluespotted poacher in B.C.)

Peer, Donald Lloyd
S 1482 (study of eutrophicated marine basin)

Pelecypoda; Bivalvia; Lamellibranchia (*see also* Mollusca; *also* Clam; Mussel; Oyster; Scallop)
T 225 (associated with Bay of Fundy scallop beds)
S 1469 (occurrence of *Cristispira* spirochaete commensal in 12 of 63 W Canadian marine species)
1470 (distributional checklist of B.C. marine)

Peloscolex multisetosus (tubificid oligochaete)
J 28(3): 335 (survival of bacteria during ingestion by, in Toronto Harbour, Ont., sediments)

Pendrell Sound, B.C.
B 178 (re B.C. Pac. oyster culture)

Pepper, Vernon Alfred
J 28(5): 749 (variation in scale counts of arctic grayling)

Peprilus triacanthus (*see* Butterfish)

Peptides (*see* Polypeptides)

Perca flavescens (*see* Perch, yellow)

Perch, ocean (*see* Redfish)

Perch, Pacific ocean (*Sebastes* (*Sebastodes*) *alutus*)
J 28(3): 417 (reproductive patterns re bathymetric distribution & seasonal abundance)
T 210, 221, 269 (taken during B.C. groundfish surveys: distribution & abundance)
216, 257 (taken during B.C. & U.S. Pac. coast commercial trawling, 1969, 1970)
237 (length–weight relations, off B.C. in 1969)
246 (bibliography)
251 (length–girth relations, off B.C. in 1969)

Perch, pile (*Rhacochilus vacca*)
J 28(10): 1563 (new host of *Bomolochus cuneatus* copepod)
T 257 (taken in 1970 B.C. trawl fishery)

Perch, Sacramento (*Archoplites interruptus*)
J 28(11): 1811 (alkali tolerance in Nebraska eutrophic lakes & ponds)

Perch, shiner (*Cymatogaster aggregata*) (seaperch, shiner)
T 257 (taken in 1970 B.C. trawl fishery)

Perch, white (*Morone* (*Roccus*) *americanus*)
J 28(7): 1057 (effect of nuclear power plant discharge canal warm water on)
(9): 1285 (methylmercury in N.B.)
T 261 (bibliography for Gulf of St. Lawrence)

Perch, yellow (*Perca flavescens*)
J 28(1): 45 (populations upstream & downstream of a dammed Ont. lake)
(1): 105 (DDT residues in muscle, of Saskatchewan R.)
(5): 783 (slime as bacterial medium re keeping quality)
(5): 786 (heavy-metal concentrations in dressed, from Moose L., Man., & L. Erie)
(7): 957 (vulnerability to northern pike predation)
(9): 1285 (methylmercury in N.B.)
(12): 1883 (winter kill in Manitoulin Is. lakes (L. Huron))
T 261 (bibliography for Gulf of St. Lawrence)
A 200, 201 (mercury contamination in Man. waters & Great Lakes)

Pereira, Ronald Roy
J 28(5): 643 (gamma irradiation of whitefish *Salmonella*)

Peridineae (*see* Dinoflagellates)

Periphyton (*see also* Algae)
J 28(2): 215 (of NW Ont. experimental lakes)

Periwinkle, common (*Littorina littorea*)
J 28(5): 793 (yellow phosphorus concentration in body, N.S.)
T 217 (pollution from petroleum oil spills)
S 1569 (determination of residual fuel oil contamination in)
1572 (saturated & isoprenoid fatty acids distribution in lipids)

Perlmutter, Alfred
J 28(1): 47 (erythropoiesis in *Trichogaster trichopterus*)

Pesticides (*see also* Insecticides)
J 28(4): 613 (organophosphate esterase inhibitor effects; anticholinesterase activity of several)
T 272 (halogenated hydrocarbons re environment: review & bibliography)
A 201 (re Great Lakes pollution & effects on fish as food)

Peters, James Eugene
T 269 (*G. B. Reed* groundfish cruise 71–1)

Peters, Marilyn Diane
S 1549 (occurrence & origin of tropylium ion in the mass spectra of arylboronic acid esters)

Peterson, Richard Harry
S 1556 (effects of temperature on brain oxygen in salmonid fishes)

Petroleum oils (as pollutants) (*see* Oils, petroleum)

Petrolisthes (crabs)
J 28(10): 1527 (*P. cinctipes* range extension off B.C.)

Petromyzon marinus (*see* Lamprey, sea; *also* Lamprey, sea (landlocked))

Pettibone, Marian Hope
J 28(10): 1393 (*Stehnelais fusca* & *S. berkeleyi*)

*p*H (*see also* Limnology; Oceanography; *also* Hardness of natural waters)
J 28(9): 1303 (effects on walleye photic behaviour)
(11): 1811 (alkalinity tolerance of Nebraska freshwater fishes)
T 202 (effects on river diatoms caused by heavy-metal contamination of water)

Phalacrocorax auritus (*see* Cormorant, double crested)
carbo (*see* Cormorant, common)

Phanerodon furcatus (*see* Seaperch, white)

Pharmacology
B 177 (re paralytic shellfish poisoning)

Phenotypes (*see* Genes; Polymorphism)

Philonema; *Philometra* (*see* Nematoda)

Phoca groenlandicus (*see* Seal, harp)
hispada (*see* Seal, ringed)
vitulina concolor (*see* Seal, Atlantic harbour)

Phocanema decipiens (*see* Nematoda)

Phocoena phocoena (*see* Porpoise, harbour)

Phocoenoides dalli (*see* Porpoise, Dall)

Pholis gunnellus (*see* Gunnel, rock)

Phosphatases (*see* Enzymes)

Phosphates (for general data re content in natural waters *see* Nutrients, aquatic; Waters, natural; *also* Limnology; Oceanography) (for phosphatases, *see* Enzymes; *see also* Eutrophication; Pollution)
J 28(2): 171, 203, 295 (in waters of many small NW Ont. lakes)
(2): 203 (effects on photosynthesis when added to samples of water from small NW Ont. lakes)
(2): 215 (content of periphyton in 4 small NW Ont. lakes)
(2): 277 (in sediments of 16 small NW Ont. lakes)
(11): 1763 (eutrophication of small NW Ont. lake upon addition of)
T 258 (toxicity tests of trisodium nitrilotriacetate detergent as replacement for phosphate detergent, re pollution)
265 (in sea waters & ice, Frobisher Bay, Baffin Is., N.W.T.)
S 1467 (automated measurement of, in sea water)
A 216 (re eutrophic pollution in the Great Lakes)
226 (nucleoside cyclic phosphate diesterases)
227 (nucleotide phosphomonoesterases)

Phosphatides (*see* Nucleosides)

Phospholipids (*see also* Lipids)
J 28(4): 601 (fatty acids of sand launce)
S 1564 (fatty acids composition of sea anemone *Metridium dianthus*)

Phosphorescence (*see* Bioluminescence)

Phosphorus, elemental (for phosphorus derivates *see* accompanying Phosph... headings)
J 28(5): 793 (accumulation in lobster tissues, & in body of clam, quahaug, mussel, periwinkle & starfish, N.S. coast; also clearing rate)
T 233 (content of bottom deposits, Long Bay, Nfld.)
254 (levels in water, Long Harbour, Nfld.)
255 (relative toxicities of production wastes to seawater-maintained fish)
A 223 (combating pollution by, Long Harbour, Nfld.)
232 (^{32}P as radioactive marine pollutant)

Phosphorylases (*see* Enzymes)

Photography
J 28(11): 1805 (estimating distances between schooling aquarium fish by simultaneous)

Photoperiods (*see* Darkness; Diel habits; Light, reactions to)

Photophores (*see* Bioluminescence)

Photosynthesis (*see also* Algae; Chlorophylls; Phytoplankton; Pigments; Plankton; Productivity, primary; Radiation)
J 28(2): 189, 203 (liquid scintillation method for ^{14}C activity re photosynthesis in several small NW Ont. lakes)
(2): 203 (by phytoplankton in artificially enriched samples of water from several small NW Ont. lakes)
(2): 215 (by periphyton of 4 small NW Ont. lakes)
(5): 790 (nitrogen, phosphorus, & iron enrichment effects on, in N Pac. phytoplankton)

Phototrophy (*see* Light, reactions to; Productivity, primary)

Phoxinus eos (*see* Dace, northern redbelly)

Phycis chesteri (*see* Hake, longfin)

Phylogeny
J 28(3): 427 (osteology re phylogenetic implications in the Aulorhynchidae & Gasterosteidae)
(6): 879 (lobster enolase re other enolases)
S 1588 (*Harnischia* complex of chironomids)

Physa (*see* Snails, freshwater)

Physiography (*see* Geology; Geomorphology; Glaciation; Morphometry (physical))

Physiology (*see also* aspects of)
J 28(1): 7 (seasonal changes in composition & food reserves in flatworm)
(1): 73 (energetics of a dipteran in thermal springs)
(1): 95 (differential growth rate of Pac. big skate tail)
(3): 343 (salinity effects on pre-smolt coho salmon survival & growth)
(3): 379 (dissolved oxygen requirements for northern quahaug early development)
(3): 409 (sockeye salmon feed intake)
(3): 417 (Pac. ocean perch reproductive patterns)
(3): 449 (bluegill sunfish protein consumption & nitrogen excretion)
(5): 625, 635 (effects of handling, anesthetization, & surgery of brook trout)
S 1526 (evidence for pituitary adrenocortical feedback system in eel)
1550 (of Atl. sea raven gill proprioceptors re respiration)
A 222 (assessment of pollutant effects on fish)

Phytane (*see* Hydrocarbons)

Phytoflagellates (*see Dinoasteromonas*; Flagellates)

Phytomacrofauna
J 28(9): 1322 (quantitative sampler for aquatic)

Phytoplankton (*see also* Algae; Chlorophylls; Feed; Grazing; Limnology; Oceanography; Plankton; Production, primary; *also* classifications of phytoplankton)
J 28(2): 189, 203, 215 (re primary production & photosynthesis in several small NW Ont. lakes)
(2): 295 (re differences & similarities among small NW Ont. lakes)
(5): 790 (nitrogen, phosphorus, & iron enrichment effects on photosynthesis & assimilation ratios of N Pac.)
(11): 1763 (change in dominant species on adding phosphate & nitrate to small NW Ont. lake)
T 247 (production & nutrients, Bedford Basin, N.S., 1969–70)
248 (grazed by zooplankton, re marine productivity)
267 (tables, Frobisher Bay, Baffin Is., N.W.T., 1967)
S 1482 (community structure of eutrophicated Bedford Bay, N.S., vs. St. Margaret's Bay, N.S.)
1485 (role of aquatic organic matter as feed for)
1513 (re zooplankton grazing, re marine productivity)
1538 (energy flow & species diversity in bloom of marine)
1577 (Como Creek, Colorado)
1578 (coastal waters of Ellesmere Is., N.W.T.)
1579 (annual production, St. Margaret's Bay, N.S.)
1586 (chlorophyll production budget over a 25-hour period, Bedford Basin, N.S.)
A 211 (re feed availability to different trophic levels in marine feed chain)
220 (program during C.S.S. *Hudson* oceanographic survey circumnavigating N & S America)

Pickard, George Lawson
J 28(8): 1077 (oceanographic features of Chile inlets)

Pickerel, chain (*Esox niger*)
J 28(9): 1285 (methylmercury in N.B.)

Pickerel, grass (*Esox americanus vermiculatus*)
J 28(4): 613 (blood plasma esterase activity)

Pigments; Pigmentation (*see also* Chlorophylls)
J 28(4): 477 (androgen-induced nuptial skin coloration in gonadectomized male sockeye salmon)
(4): 509 (brook trout skin & flesh pigments after feeding crustacean wastes plus canthaxanthin)
(10): 1672 (ambicoloration in a petrale sole)
(11): 1789 (melanin distribution in butter clam re paralytic shellfish toxin retention)

T 220 (effects of storage of sockeye salmon in ice vs. refrigerated sea water, on colour of canned product)
A 203 (salmon flesh colour enhancement for canning)

Pike, northern (*Esox lucius*)
J 28(1): 105 (DDT residues in muscle, of Saskatchewan R.)
(4): 613 (blood plasma esterase activity)
(5): 783 (slime as bacterial medium re keeping quality)
(5): 786 (survey of heavy-metal concentrations in dressed, from Moose L., Man., L. St. Pierre, & L. Erie)
(7): 957 (vulnerability of 17 species to predation by)
(7): 1061 (practical drying equipment for steaks & fillets)
(9): 1325 (postmortem changes in muscle glucogen phosphorylase activity)
(11): 1811 (alkalitolerance in Nebraska eutrophic lakes & ponds)
(12): 1883 (winter kill in Manitoulin Is. lakes (L. Huron))
T 261 (bibliography for Gulf of St. Lawrence)
A 200, 201 (mercury contamination in various Canadian rivers & lakes)
224 (incidence of *Trianeophorus crassus* in Heming L., Man.)

Pillinger, Colin Trevor
S 1528 (geological fate of chlorophyll)

Pimephales notatus (*see* Minnow, bluntnose)
promelas (*see* Minnow, fathead)

Pinhorn, Allenby Thomas
S 1493 (effects of increases in mesh sizes of trawls)
1540 (catch/effort assessment of major cod stocks)

Pinnotheres (crabs)
J 28(10): 1527 (*P. pugettensis* & *P. taylori* range extension off B.C.)

Pipefish, northern (*Syngnathus fuscus*)
T 261 (bibliography for Gulf of St. Lawrence)

Pippy, John Herbert Charles
J 28(3): 461 (record of Atl. menhaden from Northumberland Strait)
T 226 (Miramichi R. fish mortalities)
S 1520 (food of giant squid)
A 58(F) ("swimmers' itch")

Piscicides (*see also* Insecticides)
S 1484 (molecular structure of halogenated mononitrophenols re their toxicities to sea lamprey larvae & rainbow trout fingerlings)

Pisidium (*see* Clams)

Pitt, Thomas Kenton
J 28(3): 456 (fecundity of yellowtail flounder from Grand Bank, Nfld.)
S 1541 (trends in American plaice fishery)

Pituitary gland
J 28(4): 477 (histological effects of hormones & cortisol on gonadectomized sockeye salmon)
S 1526 (physiological evidence for pituitary-adrenocortical feedback mechanism in eel)
1535 (chinook salmon gonadotropin effect on sexual behaviour of hypophysectomized & gonadectomized female guppies)

Placentia Bay; Long Bay; Long Harbour, Nfld.
T 233 (bottom deposits content of elemental phosphorus & fluorides)
254 (elemental phosphorus levels in water)
S 1539 (capacity to accept pollutants)

Placid Lake, B.C.
J 28(9): 1259 (segregation between adult cutthroat & Dolly Varden trouts)

Placopecten magellanicus (*see* Scallop, sea)

Plaice, Alaska (*Pleuronectes quadrituberculatus*)
T 246 (bibliography)

Plaice, American (*Hippoglossoides platessoides*)
J 28(1): 1 (amine formation in stored frozen muscle)
(7): 935 (regular component of Passamaquoddy Bay fish communities, N.B., & length frequencies)
(8): 1125 (purines changes in iced fillets)
(9): 1285 (methylmercury in, N.S. banks)
T 260 (availability, standing crop, lengths, weights, etc. from Scotian Shelf surveys, 1958–68)
261 (bibliography for Gulf of St. Lawrence)
272 (halogenated hydrocarbon residues detected in)
S 1541 (fishery trends in ICNAF Subarea 3)
A 181, 182 (ICNAF Canadian 1969 research summaries)
191 (ICNAF report on egg & larvae numbers in Davis & Denmark Straits)
194 (Nfld. fishery)

Planes (crabs)
J 28(10): 1527 (*P. marinus* range extension off B.C.)

Plankton (*see also* Algae; Diatoms; Phytoplankton; Production, primary; Zooplankton
J 28(2): 189, 203, 215, 231, 245, 257 (studies of many small NW Ont. lakes)

(3): 311 (crustacean, of 146 W Canadian alpine & subalpine lakes & ponds)
(11): 1783 (^{65}Zn vs. Zn distribution in experimental marine ecosystem)
T 252 (high-speed sampler)
A 181, 182 (ICNAF Canadian 1969 research summaries)

Plants (*see* Flora, aquatic; Flora, terrestrial)

Plasma (*see* Blood; Enzymes; Hormones; Proteins; Serum)

Platford, Robert Frederick
S 1512, 1515 (isopiestic measurements)

Platichthys stellatus (*see* Flounder, starry)

Platidia hornii (Brachiopoda)
T 268 (in B.C. faunistic surveys since 1960)

Platt, Trevor Charles
T 247 (phytoplankton production & nutrients in Bedford Basin)
S 1482 (study of eutrophicated marine basin)
1538 (marine energy flow)
1579 (production by phytoplankton in St. Margaret's Bay, N.S.)
1586 (effect of plankton grazing in small marine basin)

Platyhelminthes (*see* Cestoda; Trematoda; Turbellaria)

Plecoptera (*see* Stoneflies)

Pleuronectes quadrituberculatus (*see* Plaice, Alaska)

Pleuronectidae (righteye flounders) (*see also* names of species)
T 246 (bibliography of N America Pac. coast)

Pleuronichthys coenosus (*see* Sole, C-O)
decurrens (*see* Sole, curlfin)
verticalis (*see* Turbot, hornyhead)

Plocamionida (*see* Sponges)

Plutonium
A 232 (^{238}Pu as radioactive marine pollutant)

Poacher, Atlantic (*Agonus decagonus*)
T 161 (bibliography for Gulf of St. Lawrence)

Poacher, bluespotted (*Xeneretmus triacanthus*)
J 28(9): 1347 (range extension N into B.C.)

Poacher, sturgeon (*Agonus acipenserinus*)
T 257 (taken in 1970 B.C. trawl fishery)

Poecilia reticulata (*see* Guppy)

Poisons (*see* Pollution; Toxicants)

Polinices heros (*see* Clam drill, greater)

Polistotrema stouti (*see* Hagfish, Pacific)

Pollachius virens (*see* Pollock)

Pollock (*Pollachius virens*)
J 28(1): 1 (dimethylamine formation in dark muscle during frozen storage)
(7): 935 (winter periodic component of Passamaquoddy Bay fish communities, N.B., & length frequencies)
(8): 1125 (purines changes in iced fillets)
(9): 1285 (methylmercury in, N.S. banks)
T 261 (bibliography for Gulf of St. Lawrence)
A 182 (ICNAF Canadian 1969 research summary)

Pollock, Pacific (*see* Pollock, walleye)

Pollock, walleye (*Theragra chalcogramma*) (bigeye; Pacific walleye; whiting)
T 210, 221 (catches during B.C. groundfish surveys)
246 (bibliography)
257 (catches in 1970 B.C. trawl fishery)

Pollution (*see also* Eutrophication) (*Note*: Certain entries hereunder are also conveniently segregated under headings such as Insecticides; Mercury and derivatives; Oils, petroleum; Phosphates; Phosphorus, elemental; Pulpmill effluents; etc.)
J 28(1): 59 (DDT residues in N.B. & P.E.I. marine fishes & shellfishes)
(1): 105 (DDT residues in Saskatchewan R. fishes)
(4): 610 (dieldrin residues in green sunfish blood & brain)
(5): 655 (long-term tests of copper sulphate effects on brook trout adults, eggs, & fry)
(5): 705 (biological magnification of insecticides by freshwater invertebrates)
(5): 786 (survey of heavy-metal concentrations in dressed Canadian fishes from industrial vs. non-industrial area lakes)
(5): 793 (yellow phosphorus accumulation in N.S. coast seaweeds & invertebrates; also clearing rate)
(7): 1043 (nitrilotriacetic acid assay method for inland waters)
(7): 1057 (discharge from nuclear power plants)
(8): 1107 (mathematical model of superimposed mortality in fathead minnow populations due to zinc)
(9): 1225 (cadmium toxicity tests on various marine organisms)
(9): 1285 (methylmercury in Canadian Maritimes freshwater & marine fishes; also in rain & snow)
(9): 1327 (marine oil spills partly sedimented by zooplankton ingestion & defecation)
(11): 1783 (re zinc)
(11): 1807 (mobilization of mercuric sulphide from aquatic sediments into fish)

(12): 1912 (residues in Chedabucto Bay, N.S., 14 months after Bunker C fuel oil spill)
(12): 1877 (DDT accumulation & persistence in a lotic ecosystem)
B 178 (re raft-culturing of Pac. oyster in B.C.)
T 200 (possibilities of X-ray fluorescence spectrophotometry of organisms elemental composition, for assessing)
202 (effects of zinc & copper on river diatoms & water *p*H)
217 (petroleum oil; characterization re tracing source of spills affecting aquatic environment)
218 (antibacterial properties of sea water)
233 (elemental phosphorus & fluoride content of bottom deposits, Long Bay, Nfld.)
250 (computer programming for)
254 (elemental phosphorus levels in water, Long Harbour, Nfld.)
255 (relative toxicities of yellow phosphorus production wastes to seawater-maintained fish)
258 (toxicity tests of nitrilotriacetic acid detergent)
262 (hot water effluent from steam-electric power plants)
272 (of environment by halogenated hydrocarbons: review & bibliography)
S 1476 (re implementation of Canadian ocean engineering, chemical oceanography, & geochemistry)
1500 (gases from B.C. coastal water sediments close to pulpmills)
1504 (tracing pulpmill effluent dispersal in sea)
1510 (applying bioassay results re toxicities towards fish: review)
1531 (interaction of casein with polyethylenimine flocculating agent, re removal of pollutants)
1534 (flameless atomic absorption spectrophotometric procedure for mercury in fish flesh)
1536 (herbicides, insecticides, or detergents as possible cause of deformed chironomids larvae in L. Erie & Okanagan R. lakes, B.C.)
1539 (capacity of marine estuaries to accept pollutants; use of dyes to follow flushing action)
1552 (decrease in DDT residues in salmon parr after N.B. forest spraying)
1553 (mining effluent effects on NW Miramichi R. vascular plants, N.B.)
1558, 1570 (polychlorinated biphenyls in sea water; effects on *Gammarus oceanicus* amphipod)
1569 (determination of residual fuel oil contamination of aquatic animals)
1584 (herring mortality from coke-oven intermediate oil in N Sydney Harbour, N.S.)
A 178 (details of assay procedure in S 1534 above)
183 (re oceanography & ocean resources management)
187 (sewage, in confined coastal waters)
200, 201 (sources & effects of mercury contamination in Canadian fishes)
201 (re environment of Great Lakes fishes as affecting their food for man)
203 (lessening of, by recovery of protein from fish processing plant wastewater)
216 (phosphate detergents, sewage, etc., re causes of Great Lakes eutrophication (polemical))
222 (assessment of effects on fish physiology & behaviour)
223 (combating fuel oil, elemental phosphorus, sewage & pulpmill, on Canadian Atl. coast)
230 (re a northern environment as sources of food for man)
232 (radioactivity in the marine environment: extensive summary of book)
233 (ecology re aquatic)

Polychaeta

J 28(10): 1360 (dedication of issue to Edith & Cyril Berkeley's investigation on)
(10): 1365 (list of Edith & Cyril Berkeley's publications on)
(10): 1373 (revision of *Metavermilia* serpulids & description of 3 new species)
(10): 1437 (list of 13 recognized *Dodedecaceria* cirrutulid species, & description of a new species)
(10): 1491 (first Washington coast records of *Chloeia entypa* & *Drilonereis falcata minor*)
(10): 1385 (various species as intermediate hosts of helminth parasites)
(10): 1393 (descriptions of *Stehnelais fusca* & new species *S. berkeleyi* from E Pac.)
(10): 1487 (bioluminescence in two holopelagic families of)
(10): 1483 (description of new species *Schoederella berkeleyi*, re *S. pauliani*, from off Massachusetts)
(10): 1455 (redescription of *Malacoceros indicus*)
(10): 1403 (amphipacific distribution of some 25 species)
(10): 1433 (tube-building re feeding in *Neoamphitrite robusta*)
(10): 1429 (description of new aphroditid species, *Macellicephaloides berkeleyi*, from Aleutian trench)
(10): 1469 (descriptions of new species *Syllides benedicti*, & of 6 other syllid species; also key for Syllidae)
(10): 1407 (abyssmal annelids: a new family, Fauveliopsidae, with key to genera; 2 new genera, *Berkeleyia profunda* & *Bruunilla*

Abbreviations: J — *Journal.* B — *Bulletin.* AR — *Annual Report.* R — *Review. Circular Series*: CHN — Halifax; CNG — Nanaimo; CJG — St. John's. T — *Technical Reports.* MSP — *Miscellaneous Special Publications.* S — *Studies.* A — *Interpretive Articles.*

natalensis; a new species, *Progoniada simplex*, & 23 other species; also compendium of 504 species in 242 genera & 52 families)
(10): 1445 (*Magelona berkeleyi* new species; *M. longicornis* redescription; other *M.* species)
(10): 1459 (seasonal settlement of *Polydora limicola*, *Capitella capita*, & *Hydroides pacificus*, etc. on test panels, California)
T 225 (associated with Bay of Fundy scallop beds)
266 (Frobisher Bay, Baffin Is., N.W.T.)

Polychlorinated biphenyls
T 272 (& other industrial halogenated hydrocarbons in the environment: review & bibliography)
S 1463 (identification in mixtures by mass spectrometry)
1558, 1570 (toxicity & uptake from sea water, re *Gammarus oceanicus* amphipod)
1570 (solubilized in water by non-ionic surfactants)

Polyethylenimine
S 1531 (interaction with casein, re flocculation of water impurities & pollutants)

Polymorphism
J 28(1): 15 (of American lobster esterase isozymes)
(7): 1005 (of walleye skeletal muscle malate dehydrogenase isoenzymes, re genetics)
(7): 1053 (genic, of tetrazolium oxidase in bluefin tuna blood & tissues)
(11): 1745 (serum transferrins re dwarf & large white suckers)

Polypeptides (*see also* Proteins)
S 1563 (subunits & molecular basis in rainbow & coastal cutthroat trouts hemoglobins)
1571 (re molecular basis for multiplicity of Pac. salmons & rainbow trout hemoglobins)

Polyphosphates (*see* Phosphates)

Polysaccharides (*see* Glycogen; Saccharides)

Pomatomus saltatrix (*see* Bluefish)

Pomoxis annularis (*see* Crappie, white)
nigromaculatus (*see* Crappie, black)

Pond, Stephen Garrick
T 254 (phosphorus levels in Nfld. water)

Pond, W. L.
J 28(11): 1801 (temperature selection of trout)

Ponds; Ponding (*see also* Culture)
J 28(3): 311 (crustacean plankton of 146 W Canadian alpine & subalpine ponds & lakes; definition of pond vs. lake)
CHN 42 (disinfecting lobster-holding, against gaffkemia disease bacteria)

Pontoporeia affinis (*see* Amphipoda; Crustacea)

Populations; Communities (*see also* Abundance; Exploitation; Genetics; Indicator species; Stock)
J 28(1): 35, 45 (differences in benthos & fishes upstream & downstream of a dammed Ont. lake)
(1): 49 (differences in populations of 2 salamander species, Marion L., B.C.)
(1): 65 (L. Superior lake trout population biology before lamprey invasion)
(2): 203, 215, 231, 245, 257 (plankton in many small NW Ont. lakes)
(3): 458 (response of brook trout populations to a fishery)
(7): 971 (empirical mathematical model for *Sagitta elegans* chaetognath, St. Margaret's Bay, N.S.)
(7): 1009 (discreteness of, in spring & autumn southern Gulf of St. Lawrence herring fisheries)
(8): 1107 (mathematical model of effects of pollutant superimposed mortality in fathead minnow)
(9): 1309 (white whale, Cumberland Sound, Baffin Is., N.W.T.)
(10): 1666 (Derzhavin's biostatistical analysis method for)
(10): 1573 (re mathematical models of animal production–biomass ratio)
(12): 1873 (recovery of Canadian bowhead whale, after previous exploitation)
T 224 (ringed seal data analysis computer programming).
232 (razor clams, Masset beaches, Queen Charlotte Is., & Long Beach, Vancouver Is.)
250 (computer programming fish population characterization)
S 1495 (immature Bay of Fundy herring)
1582, 1583 (Derzhavin's biostatistical analysis method for)
A 184 (dynamics, re exploitation of arctic ringed & harp seals)
196 (dynamics, re fisheries biology: book review)

Porbeagle (*Lamna nasus*)
T 261 (bibliography for Gulf of St. Lawrence)
A 182 (ICNAF Canadian 1969 research summary)

Porcupinefish (*Diodon hystrix*)
J 28(11): 1809 (new record of lymphocystis viral infection, in)

Porichthys notatus (*see* Midshipman, plainfin)

Porifera (*see* Sponges)

Poronotis triacanthus (*see* Butterfish)

Porphyridium cruentum (*see* Algae)

Porpoise, bottlenose (*Tursiops truncatus*)
S 1575 (body & heart weight, re feeding rate)

Porpoise, Dall (*Phocoenoides dalli*)
S 1575 (body & heart weight, re feeding rate)

Porpoise, harbour (*Phocoena phocoena*)
S 1575 (body & heart weight, re feeding rate)

Porpoise, Pacific white-sided (*Lagenorhynchus obliquidens*)
S 1575 (body & heart weight, re feeding rate)

Pot (*see* Trap)

Potassium derivatives
J 28(2): 171, 203 (in waters of many small NW Ont. lakes)
(2): 277 (in sediments of 16 small NW Ont. lakes)
(5): 625, 635 (level changes in brook trout after handling, anesthetization, & surgery)

Pout, Atlantic soft (*Melanostigma atlanticum*)
T 261 (bibliography for Gulf of St. Lawrence)

Pout, ocean (*Macrozoarces americanus*)
J 28(7): 935 (regular component of Passamaquoddy Bay fish communities, N.B., & length frequencies)
(9): 1285 (methylmercury in, N.S. banks)
T 260 (standing crop, availability, lengths, weights, etc. from Scotian Shelf surveys, 1958–68)
261 (bibliography for Gulf of St. Lawrence)

Povoledo, Domenico
J 28(2): 277 (surface sediment chemistry of FRB Experimental Lakes, NW Ont.)
(7): 1043 (NTA determination in inland waters)

Power plants (electrical) (*see* Nuclear power plant; Thermal power plant)

Pozar, Dusan Frank
S 1502 (automatic wet-food dispenser)

Prakash, Anand
B 177 (E Canada paralytic shellfish poisoning)
S 1482 (study of eutrophicated marine basin)

Prawn (*Pandalus platyceros*) (spot shrimp)
T 221 (taken in B.C. groundfish surveys)
S 1518 (complete biological & economic synopsis)
A 128(F) (experimental trap fishing, B.C.)

Prawns (*see also* Shrimps)
T 241 (bibliography: *Pandalus kessleri* & others)

Precipitation (chemical) (*see* Flocculating agents; Sediments)

Precipitation (rain & snow) (*see also* Climate)
J 28(9): 1285 (mercury ion in)

Precooking (*see* Cooking)

Predation (*see also* Feed; Parasites)
J 28(1): 65; (5): 771 (sea lamprey on L. Superior trouts)
(6): 801, 809, 815 (brook trout, re fish growth efficiency analysis)
(7): 957 (vulnerability of 17 fish species to northern pike)
(9): 1352 (increased predation on coho salmon fry by torrent sculpin on moonlight nights)
(10): 1493 (possible role re Adams R. sockeye salmon population fluctuations)
(10): 1663 (fur seal on Pac. herring, re offshore distribution of latter)
(10): 1503 (pink & chum salmon fry size re predation by coho salmon)
(12): 1921 (Pac. herring on young chinook salmon in a B.C. estuary)
(12): 1847 (effect of experience in, by rainbow trout)
(12): 1877 (re DDT accumulation & persistence in prey & predators)
T 231 (birds on arctic char in a small arctic lake)
S 1490 (history of lamprey invasion of Great Lakes & control measures)

Prediction (*see* Forecast)

Preservatives and preservative treatments (*see also* Quality of fishery products; *also* preservative treatments, e.g., Ice; Canning; Drying; Refrigeration; Smoking)
J 28(5): 783 (slime removal from freshwater fishes)
A 203 (for fresh & processed fishery products)

Preslan, Janet Evelyn
S 1559 (cultural characteristics of pelagic marine hymenostome ciliate)

Pressure
S 1522 (pressure-jump bomb with optical detection)

Pressure, hydrostatic (for results of routine oceanographic observations, *see* Oceanography headings)

Price, Robert James
J 28(11): 1789 (interaction between paralytic shellfish poison & melanin)

Primary productivity (*see* Productivity, primary)

Prince Edward Island (*see also* St. Lawrence, Gulf of)
J 28(1): 59 (DDT residues in smelt & shellfishes)
B 175 (economic study of oyster fishery)
T 270 (Atl. salmon catches, 1910–70)
S 1580 (classification & ordination of many shallow-water benthic samples)

Prionace glauca (*see* Shark, blue)

Pristane (*see also* Hydrocarbons)
S 1591 (in some freshwater & marine fish oils)

Processing of fish products (*see also* Canning; Cooking; Drying; Fish protein concentrate; Freshwater fish products; Oils and fats; Refrigeration; Smoking; *also* names of fishes)
A 203 (lessening pollution by wastewaters from)

Proclavellodes pillaii (*see* Copepoda)

Productivity (*see also* Productivity, primary; Productivity, secondary)
J 28(2): entire issue (re 463 small lakes in FRB Experimental Lakes Area, NW Ont.)
(7): 971 (*Sagitta elegans* chaetognath, St. Margaret's Bay, N.S.)
(9): 1309 (white whale)
(10): 1573 (production–biomass ratio re animal cohorts & populations; mathematical models)
(11): 1699 (benthic macroinvertebrates, L. Ontario bays)
T 231 (potential, of arctic char in a small arctic lake)
A 189 (assessment methods for fish production in fresh waters)
197 (of freshwater fishes re their metabolism: review)
220 (program during C.S.S. *Hudson* oceanographic survey circumnavigating N & S America)

Productivity, primary (*see also* Algae; Phytoplankton; Plankton)
J 28(2): entire issue (re many small lakes in FRB Experimental Lakes Area, NW Ont.)
(5): 790 (seawater enrichment effect on plankton photosynthesis)
(6): 911 (re particulate carbon:nitrogen relations, Chesapeake Bay, Md.)
T 248 (re *Calanus pacificus* copepod secondary marine productivity)
265, 267 (Frobisher Bay, Baffin Is., N.W.T.)
S 1466, 1467 (large-scale studies, N Pac. Ocean)
1513 (re *Calanus* secondary marine productivity)
1586 (25-hour study of phytoplankton chlorophyll production, Bedford Basin, N.S.)
A 188 (Saanich Inlet, B.C., marine biology)
189 (assessment methods for fresh waters)
211 (re feed availability to different trophic levels in marine feed chain)
220 (program during C.S.S. *Hudson* oceanographic survey circumnavigating N & S America)

Productivity, secondary (*see also* Feed; Zooplankton; *also* Production, primary)
J 28(2): entire issue (re many small lakes in FRB Experimental Lakes Area, NW Ont.)
(5): 711 (& energy flow of 2 amphipod species, Marion L., B.C.)
T 248 (*Calanus pacificus* culture & grazing on diatoms, re marine)
266 (zooplankton data, Frobisher Bay, N.W.T.)
S 1485 (importance & general implications of organic matter in, particularly re filter-feeding copepods)
1513 (*Calanus* grazing on diatoms, re marine)
A 188 (Saanich Inlet, B.C., marine biology)
189 (assessment methods for fresh waters)
211 (re feed availability to different trophic levels in marine feed chain)

Proprioceptors (*see* Gills)

Prosopium williamsoni (*see* Whitefish, mountain)
world distribution & parasites (*see* A 224)

Protein concentrate, fish (*see* Fish protein concentrate)

Proteins (*see also* Acids, amino; Composition, chemical; Flesh; Muscle)
J 28(3): 449 (bluegill sunfish protein consumption & nitrogen excretion)
(4): 606 (content of juvenile coho salmon blood)
(8): 1113 (calorie-to-protein ratio re brook trout culture)
(8): 1173 (glycoproteins constituents levels in Pac. salmons, trouts, & bovine blood sera)
(11): 1745 (muscle & serum of suckers)
(12): 1853 (classification of coho salmon egg)
S 1489 (binding affinities of blood proteins for sex hormones & corticosteroids in 3 Atl. fishes)
1519 (non-destructive determination in marine sediments)
1521 (of soluble fraction of 5 Pac. salmon species eggs)
1522 (isomerization kinetics with pressure-jump bomb)
1545 (electrophoretic analysis of protein systems of Atl. salmon × brown trout hybrids)
1561 (stability re sulphydryl content of rabbit & rainbow trout myosins)
A 198 (stable (as fish protein concentrate), from the seas)

Protozoa (*see also* Ciliata; Dinoflagellates; Flagellates; Phytoplankton; Plankton; Zooplankton)
A 224 (parasitic to N American, USSR, & European coregonid fishes)

Prowfish (*Zaprora silenus*)
T 257 (taken during 1970 B.C. trawl fishery)

Proximate analysis (*see* Composition, chemical)

Psettichthys melanostictus (*see* Sole, sand)

Pseudoactiniscus apentasterias (*see* Dinoflagellates)

Pseudocalanus (*see* Copepoda)

Pseudocycnidae (*see* Copepoda)

Pseudomonas (*see* Bacteria)

Pseudopleuronectes americanus (*see* Flounder, winter)

Pseudorca crassidens (*see* Whale, false killer)

Pseudovermilia (*see Metavermilia*)

Publications (*see* Bibliography; *also* following two headings)

Publications, lists of (*see also* next heading)
J 28(10): 1365 (publications by Edith and/or Cyril Berkeley, 1904–68)

Publications and Reports, Fisheries Research Board of Canada (*see also* Fisheries Research Board of Canada)
J 28(1): 119; (2): 303; (3): 463; (4): 623; (5): 797; (6): 933; (7): 1067; (8): 1221; (9): 1355; (11): 1821; (12): following index (list of 1971 and some 1970)
R 1969/1970: 149 (list of 1969 & 1970)
MSP 13(F) (FRB studies in Canadian Arctic)

Puffinus griseus (*see* Shearwater, sooty)

Puget Sound, Washington, USA
J 28(9): 1269, 1275 (estimating Pac. hake populations & density by voltage-integration echo sounding)

Pulp mill effluents (*see also* Pollution)
S 1500 (nature & amounts of gases from B.C. coastal water sediments close to pulp mills)
1504 (tracing drift in sea water by continuous turbidity measurement)
A 223 (combating, on Canadian Atl. coast)

Pumpkinseed (*Lepomis gibbosus*)
J 28(9): 1285 (methylmercury in N.B.)
A 201 (mercury contamination, Great Lakes)

Pumps
A 203 (for unloading fish from boats)

Pungitius pungitius and *Pungitius* complex (*see* Stickleback, ninespine)

Purines (*see also* Acids, nucleic; Inosine; Nucleosides)
J 28(8): 1125 (re Atl. fishes postmortem quality)
S 1523 (lingcod muscle purine & pyrimidine nucleoside phosphorylases)
1524 (lingcod muscle guanine deaminase mechanism & specificity)

Purpura lapillus (*see* Dogwinkle, Atlantic)

Purvis, Harold Arthur
J 28(4): 616 (giant American brook lampreys in upper Great Lakes)

Pusa hispada (*see* Seal, ringed)

Putrescine
S 1497, 1498 (metabolism by mycobacteria isolated from fish)

Pycha, Richard Lawrence
J 28(1): 65 (population biology of L. Superior lake trout)

Pyloric caeca (*see* Caeca, pyloric)

Pyrimidine
S 1523 (lingcod muscle purine & pyrimidine nucleoside phosphorylases)
1525 (trout liver pyrimidine deoxynucleoside phosphorylase & deoxyribosyltransferase)

Pyrrophyta
J 28(2): 195 (of several small NW Ont. lakes)
S 1491 (ability to cleave phenylalanine aromatic ring)

Q

Qadri, Sami Ullah
J 28(4): 465 (lake char postglacial distribution)
(9): 1322 (quantitative sampler for aquatic phytomacrofauna)

Quahaug, bay (*see* Quahaug, northern)

Quahaug, black (*see* Quahaug, ocean)

Quahaug, northern (*Mercenaria* (*Venus*) *mercenaria*) (bay quahaug; hardshell clam; littleneck clam)
J 28(1): 59 (DDT residues in N.B.)
(3): 379 (dissolved oxygen requirements for embryonic & larval development)
B 177 (re paralytic shellfish poisoning, E Canada)
S 1572 (saturated & isoprenoid fatty acids distribution in lipids)

Quahaug, ocean (*Arctica* (*Cyprinus*) *islandica*) (black quahaug; ocean clam)
J 28(5): 793 (yellow phosphorus concentration in body, N.S.)
B 177 (re paralytic shellfish poisoning, E Canada)

Qualicum River, B.C.
J 28(5): 647 (results for 3 generations from pink salmon eggs transplanted to)

Quality of fishery products
J 28(4): 509 (attractiveness of brook trout skin & flesh colour enhanced by feeding shrimp waste)
(5): 643 (killing *Salmonella* bacteria by ^{60}Co irradiation during lake whitefish smoking)
(5): 783 (beneficial effects of washing slime off freshwater fish)
(6): 869 (octopine in muscle as possible index of sea scallop freshness)
(8): 1125 (muscle inosine phosphate degradation re)
(8): 1217 (re ultrasonic method for distinguishing thawed frozen fish from fresh fish)
B 178 (condition of raft-cultured Pac. oysters in B.C.)
CHN 39 (determination of isopropanol residues in fish protein concentrates)
T 165(F) (muddy odour of rainbow trout)
220 (effects of storing sockeye salmon in ice vs. refrigerated sea water, on firmness, colour, etc. of canned product)
242 (as for T 220 above, using salt-fortified sea water; also effects of mishandling)
S 1460 (bacterial spoilage of halibut re pre-irradiation quality)
A 203 (progress in seafoods sanitation; also colour, odours, etc.)
230 (ecosystems, pollution, etc., re a northern environment as sources of fishery & other foods for man)

Quay, Wilbur Brooks
S 1574 (fin whale nasal structure)

Quayle, Daniel Branch
B 178 (B.C. Pac. oyster raft culture)
T 232 (breeding and growth of razor clams in B.C.)

Quebec (*see also* St. Lawrence, Gulf of)
T 270 (Atl. salmon catches, 1947–69)

Queen Charlotte Islands, B.C.
T 232 (razor clam breeding & growth, Masset beaches)

Queen Charlotte Sound, B.C. (*see also* Oceanography, Pacific east coast)
T 259 (rock sole fishery landings, 1959–69)

Quinones
S 1480 (isoprenoid quinone composition re tocopherol & vitamin K in unicellular red alga)

Quinte, Bay of, Lake Ontario
J 28(11): 1683 (benthic macroinvertebrates associations & species diversity)
(11): 1699 (macroinvertebrate production)
(11): 1715 (macroinvertebrate community metabolism)

Qureshi, Mohiy-ud-Din
J 28(8): 1173 (Pac. salmon glycoprotein constituents)

R

Rabbit
S 1509 (accelerated denaturation of muscle myosin in frozen solution)
1561 (sulphydryl content of myosins re protein stability)

Rabin, Harvey
A 180 (gaffkemia bacterial disease of lobsters)

Radiation, solar (*see also* Irradiation; Light, reactions to; Photosynthesis)
J 28(2): 157 (solar penetration regime in certain lakes of Experimental Lakes Area, NW Ont.)
A 233 (solar, as primary energy source of ecosystems)

Radiation, X-ray (*see* X-rays)

Radioactivity; Radioactive isotopes (*see also* Irradiation)
A 232 (in the marine environment & biological effects of: extensive summary of book)

Radionuclides (*see* Radioactivity; *also* names of elements)

Raft
B 178 (culture of Pac. oyster in B.C.)

Ragfish (*Icosteus aenigmaticus*)
T 221 (taken in B.C. groundfish surveys)

Rain (*see* Climate; Precipitation)

Raja binoculata (*see* Skate, big (Pacific))
erinacea (*see* Skate, little)
inornata (*see* Skate, California)
kincaidi (*see* Skate, black)
laevis (*see* Skate, barndoor)
ocellata (*see* Skate, winter)
radiata (*see* Skate, thorny)
rhina (*see* Skate, longnose)
senta (*see* Skate, smooth)
stellulata (*see* Skate, starry)

Range (*see* Distribution; Species, new records or range extensions of)

Rat
J 28(6): 843 (retention of zinc from oysters)

(11): 1793 (*see* T 229 below)
T 229 (tests for heart & liver fat deposition when fed raw & partially hydrogenated Atl. herring oil)

Ratfish (*Hydrolagus colliei*)
T 210, 221 (taken during B.C. groundfish surveys)
246 (bibliography)
257 (taken in 1970 B.C. trawl fishery)

Rations (*see also* Culture; Feed; Feedstuff; Hatcheries; Metabolism; Starvation)
J 28(6): 801, 809, 815 (levels re fish growth efficiency analysis)
(8): 1113 (calorie-to-protein ratio for brook trout)
(8): 1185 (bacterial counts of commercial fish diets)
(10): 1635 (young sockeye salmon growth responses to different diets & nutrition planes)
T 243 (for tank-cultured sablefish)
248 (zooplankton, re marine productivity)
S 1513 (zooplankton, re marine productivity)

Raven, sea (*Hemitripterus americanus*)
J 28(4): 491 (cardiac & respiratory responses to hypoxia)
(7): 935 (regular component of Passamaquoddy Bay fish communities, N.B., & length range)
(9): 1285 (methylmercury in, N.S. banks)
T 225 (associated with Bay of Fundy scallop beds)
226 (standing crop, availability, lengths, weights, etc. from Scotian Shelf surveys, 1958–68)
261 (bibliography for Gulf of St. Lawrence)
272 (halogenated hydrocarbon residues detected in)
S 1550 (gill proprioceptors)

Ray, Pacific electric (*Torpedo californica*)
T 257 (taken during 1970 B.C. trawl fishery)

Rearing (*see* Culture; Hatcheries)

Recovery (*see* Disease; Survival)

Recruitment (*see also* Mortality; Population; Stock)
J 28(10): 1666 (re population biostatistical analysis)
T 256 (effects of recent, on Georges Bank scallop fishery landed meat size)
A 206 (ICNAF forecast re haddock for 1970–72)

"Red water"
J 28(3): 391 (*Mesodinium rubrum* incomplete symbionts, ultrastructure, taxonomy)

Redfish (*Sebastes marinus* (*mentella*)) (ocean perch)
J 28(1): 1 (amine production in stored frozen muscle)
(7): 935 (regular component of Passamaquoddy Bay fish communities, N.B., & length frequencies)
(8): 1125 (purines changes in iced fillets)
T 225 (associated with Bay of Fundy scallop beds)
260 (standing crop, availability, lengths, weights, etc., from Scotian Shelf surveys, 1958–68)
261 (bibliography for Gulf of St. Lawrence)
272 (halogenated hydrocarbon residues detected in)
A 179(F) (distinction between *S. marinus marinus* & *S. marinus mentella*; biology & fishery of latter)
181, 182 (ICNAF 1969 Canadian research summaries)
194, 195 (Nfld. & Labrador fisheries)

Redhorse, northern (*see* Redhorse, shorthead)

Redhorse, shorthead (*Moxostoma macrolepidotum*) (northern redhorse)
J 28(1): 105 (DDT residues in muscle of Saskatchewan R.)

Reduction (*see* Fishmeal; Oils and Fats)

Reeves, Jerry Edwin
J 28(9): 1275 (estimation of hake population by echo integrator)

Reflex, conditioned (*see* Behaviour)

Refrigeration (*see also* Chilling; Freezing; Ice; Sea water, refrigerated; Superchilling)
J 28(1): 1 (dimethylamine & other amine formation in stored frozen muscle of various Atl. coast fishes)
S 1461 (thermistor readout monitoring system for temperatures)
1473 (portable holding unit for iced fish)
A 225 (resume of S 1473 above)

Regier, Lloyd Wesley
J 28(3): 305 (haddock fillets bacteria)
(4): 509 (brook trout pigmentation)
(7): 1055 (distillation of fluoride in soils)
CHN 39 (extraction of isopropanol in fish protein concentrates)
S 1412 (fluoride content of FPC & raw fish)
1505 (fluoride in polluted waters)

Reinhardtius hippoglossoides (*see* Halibut, Greenland)

Reish, Donald James
J 28(10): 1459 (seasonal settlement of polychaetous annelids)

Relict species (*see* Species, relict)

Reproduction (*see also* Courtship; Fecundity; Fertilization; Mating; Maturity; Spawning)
J 28(3): 417 (patterns of Pacific ocean perch re bathymetric distribution & seasonal abundance)
(5): 755 (observation of whelping colony of harbour seals, Sable Is., N.S.)
(9): 1309 (white whale, Cumberland Sound, Baffin Is., N.W.T.)
T 235 (agonistic behaviour re lobster mating)
S 1582, 1583 (mathematical comparison of 2 reproduction curves)
1590 : 552 (of fishes re temperature: review)
A 179(F) (redfish)
184 (harp & ringed seal)

Research vessel operations (*see* Vessels, research)

Respiration (*see also* Activity; Blood; Gills; Hemoglobin; Oxygen, dissolved; Respirometer; Stress)
J 28(1): 73 (*Hedriodiscus truquii* diptera larvae)
(1): 95 (re tail growth in embryo big skate)
(3): 379 (oxygen requirements for northern quahaug early development)
(4): 491 (responses to hypoxia in sea raven)
(5): 625, 635 (physiological effects of handling, anesthetization, & surgery of brook trout)
(7): 947 (blood-pressure drop in teleost gills, re blood pathway)
(8): 1119 (chronic effects of low oxygen concentrations on fathead minnow)
(9): 1342 (measuring respiratory quotient of *Tilapia mossambica*)
(10): 1609 (rainbow trout circulatory & ventilatory responses to artificial manipulation of gills)
(12): 1823 (handling & salinity effects on striped bass oxygen requirements)
(12): 1907 (factors affecting rates, in winter flounder)
S 1550 (re Atl. sea raven gill proprioceptors)
1554 (rainbow trout respiratory pumps responses to hypoxia)
A 197 (oxygen consumption re metabolic activities of fish: review)

Respirometer (*see also* Respiration)
J 28(1): 73 (for insect larval respiration rate)

Retrieval, information (*see also* Bibliographies; Indexes)
T 209 (storage & retrieval of indexed & annotated bibliographical references)

Review papers and articles (*see also* Bibliographies)
J 28(3): 391 (ultrastructure of red-water ciliate *Mesodinium rubrum*; *Mesodinium* taxonomy & key)
(10): 1583 (radioisotope X-ray fluorescent spectroscopy in aquatic biology)
AR 1970 (FRB Annual Report, with research highlights)
R 1969/1970 (FRB (biennial) Review)
T 272 (halogenated hydrocarbons industrial uses re effects on environment)
S 1487 (diseases & other effects of parasitization on fishes)
1510 (utilizing & applying bioassay results re pollutants toxicities towards fish)
1590 (temperature effects on living Fishes)
A 197 (metabolism & biological production in fish)
212 (energy cost of living, for fish)
215 (fishery by-products technology)

Reviews of books
A 186 (fish infectious diseases & control)
196 (fisheries biology; a study in population dynamics)
210 (seawater analysis methods)
228 (Jakob Danielson, Greenlandic painter)
229 (aging mammals by teeth & bone layering)

Revival
S 1590 : 533 (of fishes after supercooling: review)

Reynolds, James B.
J 28(1): 102 (bathythermograph transect data plotting)

Rhabdochona (nematodes)
J 28(10): 1645 (*R. canadensis* new species; 5 other species described; systematics; key to genus; distribution in N & Central America)

Rhacochilus vacca (*see* Perch, pile)

Rhinichthys atratulus (*see* Dace, blacknose)
cataractae (*see* Dace, longnose)

Rhodophyceae (red seaweeds) (*see* Algae; Dulse; Seaweeds)

Rhodymenia palmata (*see* Dulse)
pertusa (*see* Seaweeds)

Ribonuclease (*see* Enzymes)

Ribonucleic acid (*see* Acids, nucleic)

Ribonucleotides (*see* Nucleosides)

Ricard, Michel
T 202(F) (diatoms as indicators of mine pollution)

Richibucto, N.B.
J 28(1): 59 (DDT residues in marine fishes & shellfishes)

Ricker, William Edwin
J 28(10): 1666 (biostatistical population analysis)
S 1582 (Derzhavin's biostatistical method)
1583 (comparison of 2 reproduction curves)
A 189 (assessment of freshwater fish production)

Ridgway, George J.
J 28(1): 15 (isozyme polymorphisms in American lobsters)

Ringrose, Richard Caig
J 28(8): 1113 (calorie/protein ratio for brook trout)

RNA (ribonucleic acid) (*see* Acids, nucleic; Nucleosides)

Roach, Stewart Williard
T 220, 242 (storage of Pac. salmon at sea)

Roberts-Pichette, Patricia
S 1553 (effects of mining pollution on Miramichi R. plants)

Robins, Geoffrey Lewis
J 28(6): 861 (effects of feeding level on scales of young salmon)
(11): 1757 (response of young salmon to starvation periods)
(11): 1757 (effect of starvation on scales of salmon)

Robinson, Douglas Grant
J 28(9): 1345 (anomalous occurrence of carp in marine environment)

Roccus (*see Morone*)

Rockfish, aurora (*Sebastes* (*Sebastodes*) *aurora*)
J 28(6): 903 (habitat of a blood fluke species in)
T 221 (catches during B.C. groundfish surveys)

Rockfish, black (*Sebastes* (*Sebastodes*) *melanops*)
J 28(6): 903 (habitat of 2 blood fluke species in)
T 246 (bibliography)
257 (taken in B.C. trawl fishery, 1970)

Rockfish, blackbanded (*see* Rockfish, tiger)

Rockfish, blackblotched (*see* Rockfish, darkblotched)

Rockfish, blackmouth (*see* Rockfish, darkblotched)

Rockfish, blackthroat (*see* Rockfish, rougheye)

Rockfish, blue (*Sebastes* (*Sebastodes*) *mystinus*)
T 246 (bibliography)

Rockfish, canary (*Sebastes* (*Sebastodes*) *pinniger*) (orange rockfish)
J 28(6): 903 (habitat of 2 blood fluke species in)
T 246 (bibliography)
257 (taken in B.C. trawl fishery, 1970)
269 (catches during B.C. groundfish survey, 1971)

Rockfish, copper (*Sebastes* (*Sebastodes*) *caurinus*)
J 28(6): 903 (habitat of 2 blood fluke species in)
(10): 1563 (host of a new copepod species)
T 246 (bibliography)
257 (taken in B.C. trawl fishery, 1970)

Rockfish, darkblotched (*Sebastes* (*Sebastodes*) *crameri*) (blackblotched or blackmouth rockfish)
J 28(6): 903 (habitat of a blood fluke species in)
T 210, 221 (taken during B.C. groundfish surveys)
246 (bibliography)
257 (taken in B.C. trawl fishery, 1970)

Rockfish, flag (*Sebastes* (*Sebastodes*) *rubrivinctus*)
T 210, 221, 269 (taken during B.C. groundfish surveys)
246 (bibliography)
257 (taken in B.C. trawl fishery, 1970)

Rockfish, greenstriped (*Sebastes* (*Sebastodes*) *elongatus*)
T 221, 269 (catches during B.C. groundfish surveys)
246 (bibliography)
257 (taken in B.C. trawl fishery, 1970)

Rockfish, longspine channel (*see* Thornyhead, longspine)

Rockfish, northern (*Sebastes* (*Sebastodes*) *polyspinis*)
J 28(10): 1621 (taxonomy, distribution & biology)
T 246 (bibliography)

Rockfish, orange (*see* Rockfish, canary)

Rockfish, quillback (*Sebastes* (*Sebastodes*) *maliger*)
J 28(6): 903 (habitat of 2 blood fluke species in)
T 257 (taken in B.C. trawl fishery, 1970)

Rockfish, redstripe (*Sebastes* (*Sebastodes*) *proriger*)
J 28(6): 903 (habitat of a blood fluke species in)
T 210, 221, 269 (taken during B.C. groundfish surveys)
257 (taken in B.C. trawl fishery, 1970)

Rockfish, rosethorn (*Sebastes* (*Sebastodes*) *helvomaculatus*)
J 28(6): 903 (habitat of a blood fluke species in)
T 221 (taken during B.C. groundfish surveys)
246 (bibliography)
257 (taken in B.C. trawl fishery, 1970)

Rockfish, rougheye (*Sebastes* (*Sebastodes*) *aleutianus*)
T 221 (catches during B.C. groundfish surveys)
246 (bibliography)
257 (taken in B.C. trawl fishery, 1970)

Rockfish, sharpchin (*Sebastes* (*Sebastodes*) *zacentrus*)
J 28(6): 903 (habitat of a blood fluke species in)
T 221 (taken during B.C. groundfish surveys)
246 (bibliography)
257 (taken in B.C. trawl fishery, 1970)

Rockfish, shortraker (*Sebastes* (*Sebastodes*) *caenaematicus*)
T 221 (taken during B.C. groundfish surveys)
257 (taken in B.C. trawl fishery, 1970)

Rockfish, shortspine channel (*see* Thornyhead, shortspine)

Rockfish, silvergray (*Sebastes* (*Sebastodes*) *brevispinis*)
J 28(6): 903 (habitat of a blood fluke species in)
T 221, 269 (taken during B.C. groundfish surveys)
246 (bibliography)
257 (taken in B.C. trawl fishery, 1970)

Rockfish, spinycheeked (*see* Thornyhead, shortspine)

Rockfish, splitnose (*Sebastes* (*Sebastodes*) *diploproa*)
J 28(6): 903 (habitat of a blood fluke species in)
T 221 (taken during B.C. ground fish surveys)
246 (bibliography)
257 (taken during B.C. trawl fishery, 1970)

Rockfish, stripetail (*Sebastes* (*Sebastodes*) *saxicola*)
T 221 (catches during B.C. groundfish surveys)
246 (bibliography)

Rockfish, tiger (*Sebastes* (*Sebastodes*) *nigrocinctus*) (blackbanded rockfish)
J 28(6): 903 (habitat of a blood fluke species in)
T 246 (bibliography)

Rockfish, vermilion (*Sebastes* (*Sebastodes*) *miniatus*)
T 246 (bibliography)

Rockfish, widow (*Sebastes* (*Sebastodes*) *entomelas*)
T 210, 221, 269 (catches during B.C. groundfish surveys)
246 (bibliography)
257 (taken in B.C. trawl fishery, 1970)

Rockfish, yelloweye (*Sebastes ruberrimus*) (red snapper)
T 257 (taken in B.C. trawl fishery, 1970)

Rockfish, yellowmouth (*Sebastes* (*Sebastodes*) *reedi*)
T 221, 269 (taken during B.C. groundfish surveys),
246 (bibliography)
257 (taken in B.C. trawl fishery, 1970)

Rockfish, yellowtail (*Sebastes* (*Sebastodes*) *flavidus*)
J 28(6): 903 (habitat of 2 blood fluke species in)
T 210, 221, 269 (taken during B.C. groundfish surveys)
246 (bibliography)
257 (taken in B.C. trawl fishery, 1970)

Rockfishes (*Sebastes* (formerly *Sebastodes*)) (*see also* names of species)
J 28(6): 903 (incidence & habitat of 2 blood fluke species in, re habitat of the fish species)
T 210, 221, 269 (taken during B.C. groundfish surveys)
216 (taken during B.C. & U.S. Pac. coast commercial trawling, 1969)
246 (bibliography of N America Pac. coast)
257 (taken in B.C. trawl fishery, 1970

Rockling, fourbeard (*Enchelyopus cimbrius*)
J 28(7): 935 (summer periodic component of Passamaquoddy Bay fish communities, N.B.; length frequencies)
T 261 (bibliography for Gulf of St. Lawrence)

Roelofs, Eugene Woodrow
J 28(4): 610 (concentrations of dieldrin in blood & brain of green sunfish at death)

Romilly, Mervyn J.
S 1480 (composition of a unicellular red alga)

Ronald, Alexander Pollock
S 1563 (trout hemoglobins)
1571 (molecular basis for multiplicity of Pac. salmon hemoglobins)

Roseau River, Man.
J 28(6): 919 (temperature & light effects on prespawning brook sticklebacks)

Rotifera (*see also* Plankton; Zooplankton)
J 28(2): 245 (vertical distribution & seasonal abundance in 2 small shallow NW Ont. lakes)
(4): 559 (seasonal calorific values, from 3 small E Ont. lakes)

Roundworms (*see* Nematoda)

Roy, Joan Elaine
S 1523 (fish muscle phosphorylases)
1524 (mechanism & specificity of guanine deaminase)
1525 (fish liver enzymes)

Roy, Kenneth L.
S 1524 (mechanism & specificity of guanine deaminase)

Royer, Leroy Merne
J 28(1): 105 (residues of DDT, DDE, & DDD in Saskatchewan R. fish)

Rudderfish, banded (*Seriola zonata*)
T 261 (bibliography for Gulf of St. Lawrence)

Ruggieri, George Daniel
J 28(8): 1208 (killifish "hemagglutinogens")

Runner, blue (*Caranx crysos*)
T 261 (bibliography for Gulf of St. Lawrence)

S

Saanich Inlet, Vancouver Island, B.C.
A 188 (marine biology)
211 (feed chain)

Sable Island, N.S.
J 28(5): 755 (observations on whelping Atl. harbour seal colony)

Sablefish (*Anoplopoma fimbria*) (black cod)
J 28(10): 1629 (first record of marine fish spontaneous furunculosis)
T 210, 221, 269 (taken during B.C. groundfish surveys)
216, 257 (taken during B.C. & U.S. Pac. coast commercial trawling, 1969)
243 (culture progress, 1970)
246 (bibliography)

Saccharides
S 1530, 1548 (*Rhodymenia pertusa* seaweed cell-wall glucan chemical structure)
1585 (amylopectin accumulation in *Clostridium botulinum*)

Saether, Ole Anton
S 1532 (distribution of invertebrates)
1533 (chironomids & other invertebrates)
1536 (deformed larvae in Canadian lakes)
1588 (nomenclature & phylogeny of genus *Harnischia*)

Safe, Lorna Margaret
S 1459 (new marine sterol)

Sagavanirktok River system, Alaska
J 28(1): 115 (meristic differences between anadromous & freshwater-resident arctic char)

Sagitta (*see* Chaetognatha)

Saha, Jadu Gopal
J 28(1): 105 (residues of DDT, DDE, & DDD in Saskatchewan R. fish)

Saito, Akira
J 28(4): 509 (brook trout pigmentation)

Sakagawa, Gary Toshio
J 28(1): 65 (population biology of L. Superior lake trout)

Sakamoto, Mitsuru
J 28(2): 203 (phytoplankton production control in FRB Experimental Lakes, NW Ont.)

Salamanders
J 28(1): 49 (size, structure, & distributional patterns of *Taricha granulosa* & *Ambystoma gracile* populations in Marion L., B.C.)
T 258 (toxicity tests of trisodium nitrilotriacetate detergent on larvae, re pollution)
A 201 (mercury contamination, L. St. Clair, Ont.)

Salinity (*see also* Chloride; Chlorinity; Oceanography; Salinity, reactions to) (*Note:* The numerous data for salinity of sea waters routine observations are not indexed unless having special significance)
T 152 (computer programming salinity–temperature–pressure oceanographic data)
219 (regime in St. Margaret's Bay, N.S.)
S 1542 (& temperatures in E Nfld. waters)

Salinity, reactions to
J 28(3): 343 (re pre-smolt coho salmon survival & growth)
(4): 527 (re upper lethal temperatures for ribbed mussel)
(5): 727 (re petrale sole embryonic development)
(6): 883 (effects on Pac. cod egg development re geographical distribution)
(8): 1071 (*Clostridium botulinum* re toxin production in fish flesh)
(9): 1345 (ability of carp to migrate through brackish B.C. coastal waters)
(10): 1545 (effects on Pac. herring early development)
(12): 1823 (effects on striped bass oxygen requirements)
S 1590 : 520 (re fishes temperature tolerance)

Salmo aguabonito aguabonito (*see* Trout, golden)
aguabonito gilberti (*see* Trout, Kern River)
clarki (*see* Trout, cutthroat)
clarki clarki (*see* Trout, coastal cutthroat)
clarki henshawi (*see* Trout, Heenan Lake)
gairdneri (*see* Trout, rainbow; Trout, steelhead)
gairdneri gilberti (*see* Trout, Kern River)
irideus (*see* Trout, rainbow (*Salmo irideus*))
mykiss aguabonito (*see* Trout, golden)
roosevelti (*see* Trout, golden)
rosei (*see* Hybridization)
salar (*see* Salmon, Atlantic; Salmon, Atlantic landlocked)
trutta (*see* Trout, brown)
whitei (*see* Trout, Kern River)

Salmon (Pacific, in general) (*see also* Salmon, chinook; Salmon, chum; Salmon, coho; Salmon, pink; Salmon, sockeye; *also* Kokanee; Trout, steelhead)
J 28(4): 573 (device for enumerating migrating fry)
T 215 (photoelectric fry counter)
S 1502 (automatic wet-feed dispenser for fry)
1521 (proteins of soluble fraction of eggs of 5 species)
1571 (polypeptides re molecular basis for multiplicity of hemoglobins)
A 203 (handling for processing; flesh colour enhancement)
204 (& steelhead trout: INPFC studies, 1965)
214 (hormones to delay sexual maturity, as an advantage in fish farming to allow greater growth)

Salmon, Atlantic (*Salmo salar*) (*see also* Salmon, Atlantic landlocked)

J 28(1): 59 (DDT residues in N.B.)
(3): 351 (from Miramichi R., N.B.: relative utilization rates by Miramichi sport fishery vs. maritime commercial fisheries)
(4): 565 (olfactory epithelium electrical responses)
(5): 764 (fecundity in 2 Maine rivers)
(7): 947 (blood pathway effects on blood-pressure drop in gills)
(9): 1285 (trimethylmercury in N.B. fresh water)
T 217 (characterization of petroleum oils in spills causing pollutant toxicity to)
226 (grilse mortalities from *Aeromonas liquefaciens* bacteria disease, NW Miramichi R., N.B.)
261 (bibliography for Gulf of St. Lawrence)
270 (digest of Canadian catches by provinces 1910–70; by provincial fishery districts 1950–69; by months 1947–69; by gear types; by angling 1952–70)
272 (halogenated hydrocarbon residues detected in)
S 1477 (identification & distribution of Leydig cell homolog in testis)
1489 (binding affinities of blood proteins for sex hormones & corticosteroids in)
1502 (automatic wet-feed dispenser for fry)
1545 (electrophoretic analysis of protein & esterase systems of hybrids with brown trout)
1552 (decrease of DDT residues in parr after N.B forest spraying)
1556 (temperature effects on brain tissue oxygen consumption)
1562 (major androgens in testicular & peripheral plasma of sexually maturing)
1569 (determination of residual fuel oil contamination in)
A 181, 182 (ICNAF 1969 Canadian research summaries)
192 (recent marine fishery developments; effect of W Greenland fishery on Canadian fishery)
194 (Nfld. fishery)
202, 205 (summaries of A 192 above)
214 (hormones to delay sexual maturity, as an advantage in fish farming to allow greater growth)
222 (effects of pollutants on physiology & behaviour)

Salmon, Atlantic landlocked (*Salmo salar* (*sebago*)) (lake salmon; ouananiche; sebago salmon)
J 28(4): 505 (histology of adrenal-cortical cells of hatchery vs. wild)
(4): 537 (jaw tagging effects on growth & scale characteristics)

Salmon, chinook (*Oncorhynchus tshawytscha*) (*see also* Salmon (Pacific, in general))
J 28(4): 517 (first vibriosis records in Canadian cultured; correction on J 28(8): 1219)
(5): 745 (egg fertilization by frozen sperm plus extenders)
(8): 1173 (glycoprotein constituents levels in blood sera)
(11): 1739 (susceptibility of young to *columnaris* disease)
(12): 1921 (predation of young by Pac. herring)
CNG 90 (production by U.S. hatcheries)
T 210 (taken during B.C. groundfish surveys)
213 (size, feed, etc., taken in B.C. offshore herring surveys)
S 1508 (purification & properties of testes acid deoxyribonuclease)
1535 (gonadotropin effect on hypophysectomized & gonadectomized female guppy sexual behaviour)
1571 (polypeptides re molecular basis for multiplicity of hemoglobins)

Salmon, chum (*Oncorhynchus keta*) (*see also* Salmon (Pacific, in general))
J 28(4): 517 (first vibriosus records in Canadian cultured; correction on J 28(8): 1219)
(10): 1629 (first spontaneous furunculosis record in marine environment of)
(10): 1503 (fry size re predation by coho salmon)
(10): 1511 (bacterial flora associated with surface of stream-incubating eggs, re egg mortality)
T 213 (size, feed, etc., taken during B.C. offshore herring surveys)
S 1571 (polypeptides re molecular basis for hemaglobins multiplicity)
A 211 (re feed availability to different trophic levels in marine feed chain)

Salmon, coho (*Oncorhynchus kisutch*) (*see also* Salmon (Pacific, in general))
J 28(3): 343 (salinity effects on pre-smolt survival & growth)
(4): 533 (fish ladder role in transmitting *columnaris* disease, Columbia R.)
(4): 606 (blood chemistry values for juvenile)
(5): 745 (egg fertilization by frozen sperm plus extenders)
(8): 1173 (glycoprotein constituents levels in blood sera)
(9): 1253 (antibody production & immunity responses to columnaris disease)
(10): 1503 (chum & pink salmon fry size re predation by)
(12): 1899 (stresses caused by formalin disinfection of young)
(12): 1853 (egg proteins classification)
CNG 90 (production by U.S. hatcheries)
T 200 (X-ray spectrometric analysis for discrimination from different geographic areas)
210 (taken during B.C. groundfish surveys)
272 (halogenated hydrocarbon residues detected in L. Michigan)
S 1571 (polypeptides re molecular basis for multiplicity of hemoglobins)
A 200, 201 (mercury contamination, Great Lakes)

Salmon, landlocked (*see* Kokanee; Salmon, Atlantic landlocked)

Salmon, pink (*Oncorhynchus gorbuscha*) (*see also* Salmon (Pacific, in general))
J 28(4): 517 (first vibriosus records in Canadian cultured; correction on J 28(8): 1219)
(5): 647 (results for 3 generations from transplants of eggs to Qualicum R., B.C.)
(6): 821 (gillnet selectivity re Skeena R. fishery, B.C.)
(10): 1503 (fry size re predation by coho salmon)
(10): 1511 (bacterial flora associated with surface of stream-incubating eggs, re egg mortality)
T 213 (size, feed, etc., taken in B.C. offshore herring surveys)
234 (data & computations for racial analysis of N American, on basis of scale characteristics)
S 1571 (polypeptides re molecular basis for multiplicity of hemoglobins)
A 181 (research summary on progress of B.C. transplants to Nfld.)
211 (egg culture, also feed availability for young re different trophic levels in feed chain)

Salmon, sockeye (*Oncorhynchus nerka*) (*see also* Salmon (Pacific, in general); *also* Kokanee)
J 28(1): 110 (rate of alevin evacuation from stomach of mountain whitefish)
(3): 369 (X-ray spectrometry & multivariant analysis for chemical element composition as indicator of geographic origin)
(3): 409 (satiation time, appetite, & maximum feed intake)
(4): 477, 485 (hormones & cortisol histological effects on various tissues of gonadectomized)
(4): 513 (hypothesis for alternation in age of return of successive generations of Skeena R.)
(4): 517 (first vibriosis records in Canadian cultured; correction on J 28(8): 1219)
(6): 821 (gillnet selectivity re Skeena R. fishery, B.C.)
(6): 861 (feeding level effects on scale circulus formation, *also* on fish length & weight)
(8): 1173 (glycoproteins constituents levels in blood sera)
(9): 1269 (integrated echo voltage re echo sounding for)
(9): 1319 (perception of polarized light by yearlings, re seaward migration)
(10): 1603 (ribonucleotide reductase in testes of immature)
(10): 1493 (Adams R., B.C.: abundance pattern since 1938 re year-classes dominance)
(10): 1629 (first spontaneous furunculosis record in marine environment for)
(10): 1635 (growth responses of young to different diets & nutrition planes)
(11): 1749, 1757 (response of young after starvation periods; effects on scale growth)
T 200 (analysis of data from J 28(3): 369 reference above)
220 (effects of storage in ice vs. refrigerated sea water, on quality of canned product)
223 (data & computations for racial analysis of N American, on basis of scale characteristics)
242 (as for T 220 above, using salt-fortified sea water; also effects of mishandling)
S 1560 (deoxyribonucleic acid polymerase from immature testes)
1571 (polypeptides re molecular basis for multiplicity of hemoglobins)
A 212 (energy requirements for living, feeding, & migrating: review)

Salmon, steelhead (*see* Trout, rainbow; Trout, steelhead)

Salmons (general) (*see* Salmon (Pacific, in general))

Salmonella (*see also* Bacteria)
J 28(5): 643 (gamma irradiation effects on, in smoked lake whitefish)
(8): 1185 (bacteria counts in commercial fish diets)

Salmonidae (*see also* Char; Cisco; Dolly Varden; Grayling; Kokanee; Salmon; Trout; Whitefish)
J 28(5): 781 (improved vascular catheterization procedure)
S 1502 (automatic wet-feed dispenser for fry culture)

Salvelinus alpinus (*see* Char, arctic)
fontinalis (*see* Trout, brook)
malma (*see* Dolly Varden)
namaycush (*see* Trout, lake)

Sameoto, Douglas Daniel
J 28(7): 971 (*Sagitta elegans* life history)
T 252 (herring along S N.S. coast)
S 1482 (study of eutrophicated marine basin)

Sammons, James Ira, III
J 28(7): 1053 (tetrazolium oxidase in N Atl. tuna)

Sampling
J 28(1): 113 (fish muscle for residues of applied anesthetics)
(3): 365 (shallow-water benthos by simple corer vs. Ekman grab)
(4): 573 (device for enumerating migrating kokanee fry)
(6): 849 (minute benthos & substrate materials in shallow streams)
(7): 1049 (interstitial water in intertidal mud)
(8): 1203 (technique for muscle from living fish)
(9): 1322 (quantitative sampler for aquatic phytomacrofauna)
T 252 (plankton at high speed)

Abbreviations: J — *Journal.* B — *Bulletin.* AR — *Annual Report.* R — *Review. Circular Series:* CHN — Halifax; CNG — Nanaimo; CJG — St. John's. T — *Technical Reports.* MSP — *Miscellaneous Special Publications.* S — *Studies.* A — *Interpretive Articles.*

256 (commercial scallop landings)

Sand dollar (*Echinarachnis parma*)
T 225 (associated with Bay of Fundy scallop beds)

Sand lances; sand launces (*see* Lance)

Sanddab, mottled (*see* Sanddab, Pacific)

Sanddab, Pacific (*Citharichthys sordidus*) (mottled sanddab)
T 246 (bibliography)
257 (taken in 1970 B.C. trawl fishery)

Sanddab, speckled (*Citharichthys stigmaeus*)
T 246 (bibliography)

Sandeman, Edward John
A 179(F) (redfish habitat, reproduction, & fishery)

Sanders, Herman Otto
J 28(5): 705 (pesticide accumulation in invertebrates)

Sandfish, Pacific (*Trichodon trichodon*)
T 257 (taken during 1970 B.C. trawl fishery)

Sandworm (*Nereis virens*)
J 28(9): 1225 (cadmium toxicity tests)

Sangalang, Gloria Josefina Balolong
S 1479 (in-vitro steroidogenesis in yellow bodies of American Atl. sturgeon)
1562 (stages of sexual development in Atl. salmon)
1576 (hormonal steroids in sturgeon plasma)

Sanitation (*see also* Quality of fishery products)
J 28(5): 783 (effects of washing slime off freshwater fish on keeping quality)
A 203 (progress in, re seafoods quality)

Sarcoma (*see* Tumors)

Sarda sarda (*see* Bonito, Atlantic)

Sardine (*see also* Herring, Atlantic)
A 208 (origin of N.B. "sardine" herring)

Sarot, Daniel Arthur
J 28(1): 47 (erythropoiesis in *Trichogaster trichopterus*)

Saskatchewan River, Sask.
J 28(1): 105 (DDT residues in fishes muscle)
A 200 (mercury contamination of fishes in river system)

Sauger (*Stizostedion canadense*)
J 28(1): 105 (DDT residues in muscle, of Saskatchewan R.)

Saunders, Claud Richard
J 28(5): 705 (pesticide accumulation in invertebrates)

Saunders, Richard Lee
J 28(4): 491 (hypoxic responses in the sea raven)
S 1550 (proprioceptors in gills of teleosts)
1554 (responses of respiratory pumps to hypoxia in rainbow trout)

Saury, Atlantic (*Scomberesox saurus*)
T 261 (bibliography for Gulf of St. Lawrence)

Savan, Milton
J 28(7): 1064 (infectious pancreatic virus in brook trout)

Savitz, Jan
J 28(3): 449 (nitrogen excretion and protein consumption of the bluegill sunfish)

Saxidomus giganteus (*see* Clam, butter)

Scad, bigeye (*Selar crumenophthalmus*)
T 261 (bibliography for Gulf of St. Lawrence)

Scales, fish
J 28(4): 537 (jaw tagging effects on landlocked Atl. salmon scale characteristics)
(5): 749 (arctic grayling lateral line scale counts re N American origin)
(6): 861 (sockeye salmon feeding level effects on circulus formation)
(7): 987 (lateral series counts re systematics & evolution of western N America *Salmo* species & subspecies)
(11): 1749, 1757 (effect on growth, of young sockeye salmon after starvation periods)
CNG 91 (re rainbow trout anglers' catches, Vancouver Is.)
T 223 (data & computations for N American sockeye salmon racial analysis from scale characteristics)
234 (as for T 223 above, for pink salmon)

Scallop, giant (Atlantic) (*see* Scallop, sea)

Scallop, giant sea (Pacific) (*see* Scallop, weathervane)

Scallop, sea (*Placopecten magellanicus*) (giant scallop)
J 28(1): 59 (DDT residues in N.B.)
(6): 869 (octopine formation in stored adductor muscle as possible freshness index)
(9): 1285 (methylmercury in, N.S. banks)
B 177 (re paralytic shellfish poisoning, E Canada)
T 225 (fauna associated with Bay of Fundy scallop beds)
256 (effects of recent recruitment on landed meat sizes of Georges Bank scallop fishery, 1970)
S 1459 (new sterol type (C_{26}) isolated from muscle)
1506 (identification of various muscle sterols)
A 182 (ICNAF Canadian 1969 research summary)

Scallop, weathervane (*Patinopecten caurinus*) (giant sea scallop)

J 28(4): 608 (Alaskan hermaphroditic specimen)
(9): 1335 (age & growth, Strait of Georgia & outer Washington coast)

Scaphopoda (*see also* Mollusca)
T 225 (associated with Bay of Fundy scallop beds)

Scarratt, David Johnson
J 28(11): 1733 (productivity of seaweed–lobster communities)

Scherer, Eberhard
J 28(9): 1303 (photic behaviour of walleye)

Schindler, David William
J 28(2): 139 (geography & bathymetry of selected basins of FRB Experimental Lakes, NW Ont.)
(2): 157 (light, temperature, & oxygen regimes of selected FRB Experimental Lakes, NW Ont.)
(2): 171 (chemical characterization of FRB Experimental Lakes, NW Ont.)
(2): 189 (primary production & phytoplankton of FRB Experimental Lakes, NW Ont.)
(2): 245 (zooplankton distribution & abundance in 2 FRB Experimental Lakes, NW Ont.)
(2): 295 (differences & similarities in FRB Experimental Lakes, NW Ont.)
(4): 559 (freshwater zooplankton calorific values)
(11): 1763 (eutrophication of 1 of FRB Experimental Lakes, NW Ont.)

Schooling
J 28(7): 999 (spacing & density as criteria for distinguishing from aggregation of fish)
(7): 1019 (effects on dispersal of introduced rainbow trout)
(11): 1805 (estimating photographically distances between fish in an aquarium)

Schreck, Carl Bernhard
J 28(7): 987 (Kern R. trouts)

Schroederella (Polychaeta Sedentaria)
J 28(10): 1483 (new species *S. berkeleyi*, re *S. pauliani*)

Scomber colias (*see* Mackerel, chub)
japonicus (*see* Mackerel, chub)
scombrus (*see* Mackerel, Atlantic)

Scomberesox saurus (*see* Saury, Atlantic)

Scopthalamus aquosus (*see* Windowpane)

Scorpaenichthys marmoratus (*see* Cabezon)

Scorpaenidae (*see also* Rockfishes; *also* individual species)
T 246 (bibliography of N America Pac. coast)

Scotian Shelf, off Nova Scotia
T 252 (herring larvae ecology & macrozooplankton biomass)
260 (groundfish abundance & other data, 1958–68 surveys)

Scott, David Paul
J 28(11): 1807 (mobilization of mercury into fish)

Scott, James Stuart
T 260 (abundance of Scotian Shelf groundfishes)
S 1483 (*Lecithophyllum botryophorum* in *Argentina silus*)
A 182 (reports on researches in ICNAF area, 1969)

Scott, Kenneth Randall
J 28(8): 1196 (monitoring fish tank oxygen)
S 1461 (thermistor readout monitors cold storage)
1473 (portable refrigerated fish holding unit)

Screens
T 264 (fluid mechanics of netting & low-solidity screens)

Scrivener, James Charles Edward
J 28(7): 1062 (detecting burrowed lobster)
T 235 (agonistic behaviour of the American lobster)
241 (bibliography of economically important shrimps)

Sculpin, arctic (*Myoxocephalus scorpioides*)
T 261 (bibliography for Gulf of St. Lawrence)

Sculpin, arctic hookear (*Artediellus uncinatus*)
J 28(7): 935 (occasional component of Passamaquoddy Bay fish communities, N.B.)
T 261 (bibliography for Gulf of St. Lawrence)

Sculpin, arctic staghorn (*Gymnocanthus tricuspis*)
T 261 (bibliography for Gulf of St. Lawrence)

Sculpin, fluffy (*Oligocottus snyderi*)
J 28(6): 928 (feed in tidepools, cohabiting with tidepool sculpins)

Sculpin, great (*Myoxocephalus polyacanthocephalus*)
T 257 (taken in 1970 B.C. trawl fishery)

Sculpin, longhorn (*Myoxocephalus octodecemspinosus*)
J 28(7): 935 (regular component of Passamaquoddy Bay fish communities, N.B., & length frequencies)

(9): 1285 (methylmercury in Bay of Fundy & N.S. banks)
T 260 (standing crop, availability, lengths, weights, etc. from Scotian Shelf surveys, 1958–68)
261 (bibliography for Gulf of St. Lawrence)

Sculpin, mailed (*see* Sculpin, moustache)

Sculpin, mottled (*Cottus bairdi*)
J 28(1): 45 (populations upstream & downstream of a dammed Ont. lake)

Sculpin, moustache (*Triglops murrayi*) (mailed sculpin)
J 28(7): 935 (occasional component of Passamaquoddy Bay fish communities, N.B.)
T 261 (bibliography for Gulf of St. Lawrence)

Sculpin, Pacific staghorn (*Leptocottus armatus*)
J 28(10): 1563 (new host of *Holobomolochus spinulus* copepod)
T 257 (taken in 1970 B.C. trawl fishery)

Sculpin, polar (*Cottunculus microps*)
T 261 (bibliography for Gulf of St. Lawrence)

Sculpin, ribbed (*Triglops pingeli*)
T 261 (bibliography for Gulf of St. Lawrence)

Sculpin, shorthorn (*Myoxocephalus scorpius*)
J 28(7): 935 (occasional component of Passamaquoddy Bay fish communities, N.B.)
T 261 (bibliography for Gulf of St. Lawrence)

Sculpin, spatulate (*Icelus spatula*)
T 261 (bibliography for Gulf of St. Lawrence)

Sculpin, tidepool (*Oligocottus maculosus*)
J 28(3): 383 (high-tide movements & homing behaviour)
(6): 928 (feed in tidepools, cohabiting with fluffy sculpins)
(10): 1563 (new host of *Holobomolochus spinulus* copepod)

Sculpin, torrent (*Cottus rhotheus*)
J 28(9): 1352 (increased predation on coho salmon fry on moonlight nights)

Sculpin, twohorn (*Icelus bicornis*)
T 261 (bibliography for Gulf of St. Lawrence)

Sculpins (Cottidae) (*see also* Cabezon)
J 28(12): 1922 (first B.C. record of *Icelus spiniger*)
T 246 (bibliography of Pac. N America coast)
261 (bibliography for Gulf of St. Lawrence)

Sea anemones (Anthozoa)
J 28(10): 1677 (*Pachyceriantus fimbriatus* from B.C. & Washington; synonymy with *P. torreyi* & *P. plicatus*)
S 1564 (*trans*-6-hexadecenoic acid & corresponding alcohol in lipid constituents of *Metridium dianthus*; also fatty-acids composition of lipids)

Sea level (*see also* Tides; Oceanography)
T 219 (analysis of variations, St. Margaret's Bay & Halifax Harbour, N.S.)

Sea otter (*Enhydra lutris*)
A 209 (transplantation from Alaska to B.C.)

Sea poachers (*see* Poacher)

Sea raven (*see* Raven, sea)

Sea urchins (*Strongylocentrotus*)
T 217 (pollution by Atl. coast petroleum oil spills)
225 (associated with Bay of Fundy scallop beds)
S 1569 (determination of residual fuel oil contamination in)

Sea water (*see also* Nutrients, aquatic; Oceanography; Salinity; Sea water, refrigerated; Waters, natural)
T 218 (effects on bacteria survival)
S 1467 (automated measurement of dissolved nutrients)
1472 (improved indicator for colorimetric chlorinity titrations)
1512, 1517 (isopiestic measurements of H_2O–NaCl–$MgCl_2$ (& –Na_2SO_4) ternary systems at 25 C)

Sea water, artificial
J 28(5): 788 (analysis method for ammonium-nitrogen in aquaria)

Sea water, refrigerated (for holding fishery catches) (*see also* Chilling; Freezing)
T 220, 242 (effects on sockeye salmon in normal & salt-fortified, re quality of canned product)
A 203 (resume of T 220 & 242 above)

Seal, Atlantic harbour (*Phoca vitulina concolor*)
J 28(5): 755 (observations on whelping colony, Sable Is., N.S.)
S 1573 (occurrence in lakes of Thlewiaza R., N.W.T., & improbability of being *P. v. mellonae*)

Seal, bearded (*Erignathus barbatus*)
MSP 13(F) (actual & potential Canadian Arctic fishery)
A 231 (actual & potential Canadian Arctic fishery)

Seal, harp (*Phoca* (*Pagophilus*) *groenlandicus*)
MSP 13(F) (actual & potential Canadian Arctic fishery)
S 1581 (migration surveys in Gulf of St. Lawrence & Strait of Belle Isle, using various marking & tracking devices)
A 181, 182 (Canadian fisheries & research summaries, ICNAF 1969)
184 (population dynamics & exploitation of Canadian Arctic)
194 (Nfld. fishery)
231 (actual & potential Canadian Arctic fishery)

Seal, hooded (*Cystophora cristata*)
A 182 (Canadian fisheries & research summary, ICNAF 1969)
194 (Nfld. fishery)

Seal, northern fur (*Callorhinus ursinus*)
J 28(10): 1663 (distribution off B.C. & stomach contents as clue to Pac. herring offshore distribution)

Seal, ringed (*Phoca* (*Pusa*) *hispada*)
T 224 (computer programs for population data analysis; some age group data)
MSP 13(F) (actual & potential Canadian Arctic fishery)
A 184 (population dynamics & exploitation of Canadian Arctic)
200 (mercury contamination, Hudson Bay)
231 (actual & potential Canadian Arctic fishery)

Seaperch, pile (*see* Perch, pile)

Seaperch, pink (*Zalembius rosaceus*)
J 28(5): 767 (host of new trematode species)

Seaperch, shiner (*see* Perch, shiner)

Seaperch, white (*Phanerodon furcatus*)
J 28(7): 1051 (maturity & fecundity, Tomales Bay, Calif.)

Seasnail (Atlantic) (*Liparis atlanticus*)
T 225 (associated with Bay of Fundy scallop beds)
261 (bibliography for Gulf of St. Lawrence)

Seasnail, blacksnout (*Paraliparis copei*)
T 261 (bibliography for Gulf of St. Lawrence)

Seasnail, gelatinous (*Liparis koefoedi*)
T 261 (bibliography for Gulf of St. Lawrence)

Seasnail, Greenland (*Liparis tunicatus*)
T 261 (bibliography for Gulf of St. Lawrence)

Seasnail, longfin (*see* Snailfish, longfin)

Seasnail, polka-dot (*Liparis cyclostigma*)
T 261 (bibliography for Gulf of St. Lawrence)

Seasnail, striped (*Liparis liparis*)
T 261 (bibliography for Gulf of St. Lawrence)

Season (*see also* Behaviour; *also* biological and physical phenomena affected by seasons)
J 28(4): 587 (effects on wild vs. hatchery rainbow trout metabolism)
(7): 935 (effects on fish communities components, in Passamaquoddy Bay, N.B., & in warmer waters)
(7): 1009 (discreteness of Gulf of St. Lawrence herring populations in spring & autumn fisheries)
(10): 1549 (re polychaetes settlement on test panels, California)
T 177 (re degree of paralytic shellfish toxicity in E Canada)

Seawater (*see* Sea water; Sea water, artificial; Sea water, refrigerated)

Seaweeds (*see also* Algae; Dulse; Eelgrass)
J 28(5): 778 (stipe length & environment re taxonomy of *Laminaria agardhii* & *L. longicruris*)
(5): 793 (yellow phosphorus accumulation in *Fucus vesiculosis* & *F. distichus*)
(11): 1733 (productivity re use by lobsters, etc., St. Margaret's Bay, N.S.)
S 1457 (seasonal sterols content of dulse & 3 other red seaweeds)
1530, 1548 (cell-wall glucan chemical structure in *Rhodymenia pertusa*)
1580 (classification & ordination of many shallow benthic species, P.E.I.)

Sebago (*see* Salmon, Atlantic landlocked)

Sebastes aleutianus (*see* Rockfish, rougheye)
alutus (*see* Perch, Pacific ocean)
aurora (*see* Rockfish, aurora)
brevispinis (*see* Rockfish, silvergray)
caenaematicus (*see* Rockfish, shortraker)
caurinus (*see* Rockfish, copper)
crameri (*see* Rockfish, darkblotched)
diploproa (*see* Rockfish, splitnose)
elongatus (*see* Rockfish, greenstriped)
entomelas (*see* Rockfish, widow)
flavidus (*see* Rockfish, yellowtail)
goodei (*see* Chilipepper)
helvomaculatus (*see* Rockfish, rosethorn)
maliger (*see* Rockfish, quillback)
marinus marinus (*see* Redfish)
marinus mentella (*see* Redfish)
melanops (*see* Rockfish, black)
miniatus (*see* Rockfish, vermilion)
mystinus (*see* Rockfish, blue)
nigrocinctus (*see* Rockfish, tiger)
paucispinis (*see* Bocaccio)
pinniger (*see* Rockfish, canary)
polyspinis (*see* Rockfish, northern)
proriger (*see* Rockfish, redstripe)
reedi (*see* Rockfish, yellowmouth)
ruberrimus (*see* Rockfish, yelloweye)
rubrivinctus (*see* Rockfish, flag)
saxicola (*see* Rockfish, stripetail)
zacentrus (*see* Rockfish, sharpchin)

Sebastodes (*see Sebastes*)

Sebastolobus alascanus (*see* Thornyhead, shortspine)
altivelis (*see* Thornyhead, longspine)

Secchi disk (*see* Transparency of natural waters)

Sediments; Sedimentation (*see also* Corer; Grab)
J 28(2): 139, 265, 277 (of many small NW Ont. lakes)
(3): 335 (bacterial survival during ingestion of, by tubificid oligochaetes in Toronto Harbour, Ont.)
(6): 849 (assessing character by sampler)
(6): 911 (re primary productivity, Chesapeake Bay, Md.)
(7): 1049 (sampling receptacle for interstitial water in intertidal mud flats)
(7): 1055 (mud fluoride non-fusion distillation assay method)
(9): 1327 (of fuel oil from marine spills, through ingestion & defecation by zooplankton)
(11): 1715 (re benthic macroinvertebrates community metabolism, L. Ontario bays)
(12): 1877 (DDT accumulation & persistence in)
T 233 (elemental phosphorus & fluoride content, re pollution of Long Bay, Nfld.)
S 1500 (nature & amounts of gases from B.C. coastal water sediments close to pulpmills; also mathematics of bubble formation)
1519 (protein, amino acids, & ammonia determination in marine)
1528 (fatty acids indicative of geological fate of chlorophyll in 50,000,000-year-old lake shale)
1531 (flocculating reaction, re pollutants removal)
A 199 (marine geological investigations of Gulf of St. Lawrence)
232 (pollution from removal of radionuclides from sea water)

Seeds, plant
S 1475 (confusion between C_{18} & C_{20} in fatty acids analyses)
1481 (hydrogenolysis products of fatty acids from *Euphoria longana* seed oil)

Segerstråle, Sven Gustaf
J 28(9): 1331 (population problems of glacial relict amphipod)

Seining; Seines
CJG 18: 1 (recent developments in Nfld. herring fishery)

Seki, Humitake
S 1485 (organic matter in aquatic environments)

Selar crumenophthalmus (*see* Scad, bigeye)

Selectivity of nets (*see* Nets)

Selenium derivatives
J 28(5): 786 (in dressed Canadian fishes from industrial area lakes)

Semotilus atromaculatus (*see* Chub, creek)
corporalis (*see* Fallfish)

Senecella (*see* Calanoida; Copepoda)

Sergeant, David Ernest
S 1575 (feeding rates of Cetacea)
1581 (migration and orientation in harp seals)
A 229 (review of Russian book on age determination of mammals)

Seriola zonata (*see* Rudderfish, banded)

Seromucoid
J 28(8): 1173 (levels in Pac. salmons, trouts, & bovine blood sera)

Serpulidae (*see* Polychaeta)

Serum (*see also* Blood)
J 28(8): 1173 (glycoprotein constituents levels in Pac. salmons & trouts)
(11): 1745 (esterases, lactate dehydrogenases & transferrins, of large & dwarf white suckers & longnose sucker)
B 177 (serology re paralytic shellfish poisoning)

Sewage (*see* Pollution)

Sex effects (*see also* Hermaphroditism; Hormones; Ovary; Testes)
J 28(4): 587 (on rainbow trout metabolism)

Sex ratio
J 28(3): 417 (Pac. ocean perch, Washington & B.C. coast)
(5): 771 (rainbow trout, Batchawana Bay, L. Superior)
(6): 821 (Skeena R. pink & sockeye salmon re gillnet selectivity)
A 193 (capelin)

Sexual maturity (*see* Hormones; Maturity; Ovary; Reproduction; Testes)

Shad, American (*Alosa sapidissima*)
J 28(7): 1507 (effect of warm water of nuclear power plant discharge canal)
(8): 1167 (net-avoidance behaviour tracked ultrasonically)
T 256 (taken during 1970 B.C. trawl fishery)
261 (bibliography for Gulf of St. Lawrence)

Shad, gizzard (*Dorosoma cepedianum*)
J 28(7): 957 (vulnerability to northern pike predation)
T 261 (bibliography for Gulf of St. Lawrence)

Shah, Bhagwan G.
J 28(6): 843 (zinc retention in young rats fed increasing levels of high-zinc oysters)

Shale
S 1528 (isoprenoid fatty acids indicative of geological fate of chlorophyll in ancient lake sediments)

Shand Dam (*see* Grand River, Ont.)

Shanny, arctic (*Stichaeus punctatus*)
T 261 (bibliography for Gulf of St. Lawrence)

Shanny, daubed (*Lumpenus maculatus*)
J 28(7): 935 (occasional component of Passamaquoddy Bay fish communities, N.B.)
T 261 (bibliography for Gulf of St. Lawrence)

Shanny, radiated (*Ulvaria subbifurcata*)
J 28(7): 935 (occasional component of Passamaquoddy Bay fish communities, N.B.)
T 261 (bibliography for Gulf of St. Lawrence)

Sharaf El Din, Sayed Hassan
T 219 (physical oceanography of St. Margaret's Bay)

Shark, basking (*Cetorhinus maximus*)
T 261 (bibliography for Gulf of St. Lawrence)

Shark, blue (*Prionace glauca*)
T 261 (bibliography for Gulf of St. Lawrence)

Shark, brown cat (*Apristurus brunneus*)
T 221 (taken during B.C. groundfish surveys)
257 (taken in B.C. trawl fishery, 1970)

Shark, dogfish (*see* Dogfish, spiny (Pacific))

Shark, Greenland (*Somniosus microcephalus*)
T 261 (bibliography for Gulf of St. Lawrence)

Shark, hammerhead (*see* Hammerhead, scalloped)

Shark, mako (*see* Mako, shortfin)

Shark, thresher (*Alopias vulpinus*)
T 261 (bibliography for Gulf of St. Lawrence)

Shark, white (*Carcharodon carcharias*)
T 261 (bibliography for Gulf of St. Lawrence)

Shearwater, sooty (*Puffinus griseus*)
T 210 (commonest bird observed during B.C. trawl survey off SW Vancouver Is.)

Sheepshead (*see* Drum, freshwater)

Sheldon, Raymond Wilfred
S 1503 (small particles in sea water)
1537 (universal grade scale for particulate materials)

Shell (*see also* Carapace)
J 28(9): 1335 (weathervane scallop, re growth & age, Washington coast)

Shellfish (*see also* Bivalves; Lamellibranchs; Mollusca; Shell; *also* names of species)
B 177 (cause & incidence of paralytic toxicity in E Canadian)

Shih, Chang-tai
B 176 (Canadian marine zooplankton)

Shiner, common (*Notropis cornutus*)
J 28(1): 45 (populations upstream & downstream of a dammed Ont. lake)
(9): 1285 (methylmercury in N.B.)
T 226 (mortalities from pollution, & as possible immune carriers of *Aeromonas liquefaciens* bacteria disease to salmon & suckers, NW Miramichi R., N.B.)

Shiner, golden (*Notemigonus crysoleucas*)
J 28(7): 957 (vulnerability to northern pike predation)
(9): 1285 (methylmercury in N.B.)

Shiner, spotfin (*Notropis spilopterus*)
J 28(1): 45 (populations upstream & downstream of a dammed Ont. lake)

Shiner, spottail (*Notropis hudsonius*)
J 28(7): 1507 (effect of warm water of nuclear power plant discharge canal)

Shrimp, coonstripe (*Pandalus danae*) (*see also* Shrimp, humpblack)
T 241 (bibliography)

Shrimp, glass (*Palaemonetes kadiakensis*)
J 28(5): 705 (biological magnification & degradation of insecticides by)

Shrimp, grass (*Palaemonetes vulgaris*)
J 28(9): 1225 (cadmium toxicity tests)

Shrimp, humpback (*Pandalus hypsinotus*) (coonstripe shrimp; humpy shrimp)
J 28(1): 98 (spines characterizing females re spawning history)

Shrimp, humpy (*Pandalus goniurus*) (*see also* Pandalid, benttail; Shrimp, humpback)
J 28(1): 98 (spines characterizing female re spawning history)

Shrimp, pink (*Pandalus borealis*)
J 28(1): 98 (spines characterizing females re spawning history)
(4): 509 (carotenoids, re use of processing wastes for improving brook trout pigmentation)
T 241 (bibliography)
269 (catches during B.C. groundfish survey, 1971)
S 1527 (muscle & egg sterols)

Shrimp, sand (*Crangon septemspinosa*)
J 28(9): 1225 (cadmium toxicity tests)

Shrimp, sidestripe (*Pandalopsis dispar*)
J 28(1): 98 (spines characterizing females re spawning history)
T 221 (taken in B.C. groundfish surveys)

Shrimp, smooth pink (*Pandalus jordani*)
T 241 (bibliography)

Shrimp, spot (*see* Prawn (*Pandalus platyceros*))

Shrimp, striped pink (*Pandalus montagui*)
T 241 (bibliography)

Shrimpmeal
J 28(4): 509 (for feeding brook trout to improve pigmentation)

Shrimps (*see also* Prawns)
J 28(10): 1615 (new species *Eualus berkeleyorum*, also first records of *Parapasiphaë sulcatifrons*, *Acanthephyra curtirostris*, *A. quadrispinosa* & *Systellaspis braueri* caridean species, off B.C. coast)
T 241 (bibliography)

Sialic acid
J 28(8): 1173 (levels in salmon, trout, & bovine blood sera)

Sigalionidae (*see* Polychaeta)

Sight (*see* Vision)

Silicate (for general data re content in natural waters *see* Nutrients, aquatic; *see also* Limnology; Oceanography)
J 28(2): 203 (in waters of many small NW Ont. lakes)
(2): 277 (in sediments of 16 small NW Ont. lakes)
S 1467 (automated measurement of, in sea water)

Siliqua patula (*see* Clam, razor)

Silliman, Ralph Parks
J 28(8): 1211 (experiments re fishery models)

Silverside, Atlantic (*Menidia menidia*)
T 261 (bibliography for Gulf of St. Lawrence)

Simulium arcticum (*see* Blackfly)

Siphon ("neck")
B 177 (paralytic shellfish toxin in E Canada clams, mussels, & whelk)

Sipos, John Charles
T 233 (possible toxic materials in Nfld. bottom deposits)

Size; Size distribution (*see also* Growth; Length; Weight)
J 28(1): 49 (in populations of 2 salamander species, Marion L., B.C.)
(4): 616 (giant female brook lampreys in upper Great Lakes, re average adult size)
(6): 821 (Skeena R. sockeye & pink salmon, re gillnet selectivity)
(7): 947 (teleosts, re gill blood circulation & respiration)
(7): 957 (re vulnerability of fishes to predation by northern pike)
(10): 1545 (Pac. herring early larvae raised under various temperature–salinity combinations)
(10): 1503 (pink & chum salmon fry, re predation by coho salmon)
(10): 1621 (northern rockfish, re age & sex)
CNG 91 (steelhead trout, in Vancouver Is. stream-anglers' catches)
T 251 (girth re length of Pac. ocean perch off B.C. in 1969)
S 1503 (re occurrence & formation of small particles in sea water)
1537 (comparison of several grade scales, & proposed universal grade scale for particulate materials)
A 197 (& weight of fish re metabolic energy requirements: reviews)
207 (composition, N.B. & N.S. herring)
211 (particulate matter, re feed availability to different trophic levels in marine feed chain)

Skaha Lake, B.C.
S 1536 (deformed chironomids larvae possibly caused by synthetic chemical pollutants)

Skate, barndoor (*Raja laevis*)
J 28(7): 935 (occasional component of Passamaquoddy Bay fish communities)
T 261 (bibliography for Gulf of St. Lawrence)

Skate, big (Pacific) (*Raja binoculata*)
J 28(1): 95 (differential tail growth in embryo, re respiration mode)
T 246 (bibliography)
257 (taken in B.C. trawl fishery, 1970)

Skate, black (*Raja kincaidi*)
T 246 (bibliography)

Skate, California (*Raja inornata*)
T 246 (bibliography)

Skate, little (*Raja erinacea*)
J 28(7): 935 (winter periodic component of Passamaquoddy Bay fish communities, N.B., & length frequencies)
T 261 (bibliography for Gulf of St. Lawrence)

Skate, longnose (*Raja rhina*)
T 246 (bibliography)
257 (taken in B.C. trawl fishery, 1970)

Skate, smooth (*Raja senta*)
J 28(7): 935 (occasional component of Passamaquoddy Bay fish communities, N.B.)
T 261 (bibliography for Gulf of St. Lawrence)

Skate, starry (*Raja stellulata*)
T 257 (taken in 1969 & 1970 B.C. trawl fishery)

Skate, thorny (*Raja radiata*)
J 28(7): 935 (regular component of Passamaquoddy Bay fish communities, N.B., & length range)
(9): 1285 (methylmercury in Bay of Fundy & N.S. banks)
T 261 (bibliography for Gulf of St. Lawrence)
S 1489 (binding affinities of blood proteins for sex hormones & corticosteroids in)

Skate, winter (*Raja ocellata*)
J 28(7): 935 (winter periodic component of Passamaquoddy Bay fish communities, N.B., & length range)
T 261 (bibliography for Gulf of St. Lawrence)

Skates (Atlantic)
T 260 (standing crop, availability, sizes, lengths, etc. from Scotian Shelf surveys, 1958–68)

Skates, (Pacific)
T 221, 269 (taken in B.C. groundfish surveys, 1970–71)
246 (bibliography)

Skauen, Donald Matthew
J 28(5): 769 (simple, reliable method for assaying ^{14}C-labelled benthic microflora)

Skeena River, B.C.
J 28(4): 513 (hypothesis for age of return alternation in successive sockeye salmon generations)
(6): 821 (gillnet selectivity re sockeye & pink salmon fisheries)

Skeleton (*see* Osteology)

Skin
J 28(1): 104 (morphology of bacterium causing lesions on rainbow trout)
(4): 485 (histological effects of hormones & cortisol on gonadectomized adult sockeye salmon)
(4): 509 (attractiveness of brook trout enhanced by feeding crab & shrimp wastes)
(9): 1241 (incidence & comparison of tumours on Pleuronectidae of Bellingham Bay, Wash.)
(10): 1672 (ambicoloration of a petrale sole)

Skipjack (*see* Tuna, skipjack)

Slime, fish
J 28(5): 783 (beneficial effect of removal by washing, on keeping quality of freshwater fish)

Smelt, American (*see* Smelt, rainbow)

Smelt, rainbow (*Osmerus mordax*) (American smelt)
J 28(1): 95 (DDT residues in N.B. & P.E.I.)
(5): 786 (heavy-metal concentrations in dressed, from L. Erie)
(7): 935 (regular component of Passamaquoddy Bay fish communities, N.B., & length frequencies)
T 255 (toxicity tests with yellow phosphorus)
261 (bibliography for Gulf of St. Lawrence)
S 1474 (exceptional occurrence of odd-chain fatty acids, also fatty acid composition of triglycerides, cephalins, & lecithins in)

Smelt, whitebait (*Allosmerus elongatus*)
J 28(10): 1681 (first record from Juan de Fuca Strait, B.C.)

Smith, Barbara
J 28(1): 1 (DMA in muscle of gadoid fish)

Smith, Charlie Edward
J 28(1): 112 (leukemia in *Salmo clarki*)

Smith, Howard Donald
J 28(4): 573 (enumerating kokanee fry)

Smith, Janice Elaine
T 216 (summary report B.C. trawl fishery 1969)
257 (statistics on B.C. trawl fishery)
259 (commercial landings of western Canadian rock sole)

Smith, Manning Amison
S 1484 (molecular structure & biological activity among mononitrophenols containing halogens)

Smith, Michael Stuart
J 28(10): 1672 (ambicoloration in petrale sole)
T 221 (*G. B. Reed* groundfish cruise 70–3)
243 (1970 sablefish culture progress)
269 (*G. B. Reed* groundfish cruise 71–1)

Smith, Thomas Georges
T 224 (computer programs for ringed seal population data)
S 1573 (harbour seal in Thlewiaza R., N.W.T.)

Smoking; Smoked products
J 28(5): 643 (killing *Salmonella* bacteria by ^{60}Co irradiation during lake whitefish processing)

Smolts (*see* names of adult fish, e.g., Salmon, Trout)

Snail, eastern mud (*Nassarius obsoletus*) (*see also* Snails (freshwater))
J 28(9): 1225 (cadmium toxicity tests)
A 58(F) (carrier of fluke larvae causing "clam-diggers' itch" dermatitis on humans)

Snail, moon (*see* Clam drill, greater) (*see also* Snails (freshwater))

Snails (freshwater)
A 58(F) (*Lymnea emarginata, L. stagnalis* & *Physa* as carriers of fluke larvae causing "swimmers' itch" dermatitis on humans)

Snailfish, longfin (*Careproctus longipinnis*) (longfin seasnail)
T 261 (bibliography for Gulf of St. Lawrence)

Snakeblenny (*Lumpenus lumpretaeformis*)
J 28(7): 935 (regular component of Passamaquoddy Bay fish communities, N.B., & length frequencies)
T 261 (bibliography for Gulf of St. Lawrence)

Snakeblenny, fourline (*Eumesogrammus praecisus*)
T 261 (bibliography for Gulf of St. Lawrence)

Snapper, red (*Sebastes*) (*see* Rockfish, yelloweye)

Snow (*see* Precipitation)

Sodium derivatives (*see also* Composition, chemical; Salinity)
J 28(2): 171, 203 (in waters of many small NW Ont. lakes)
(2): 277 (in sediments of 14 small NW Ont. lakes)
(5): 625, 635 (level changes in brook trout from handling, anesthetization, & surgery)
S 1512, 1515 (isopiestic measurements on ternary system solutions, re NaCl & Na_2SO_4 activity coefficients)

Sole, butter (*Isopsetta isolepis*)
T 246 (bibliography)
257 (taken in B.C. 1970 trawl fishery)

Sole, C-O (*Pleuronichthys coenosus*)
T 246 (bibliography)
257 (taken in B.C. 1970 trawl fishery)

Sole, curlfin (*Pleuronichthys decurrens*)
T 246 (bibliography)
257 (taken in B.C. 1970 trawl fishery)

Sole, deepsea (*Embassichthys bathybius*)
T 246 (bibliography)

Sole, Dover (*Microstomus pacificus*)
T 210, 221, 269 (catches during B.C. groundfish surveys)
216, 257 (taken during B.C. & U.S. Pac. coast commercial trawling, 1969, 1970)
246 (bibliography)

Sole, English (*Parophrys vetulus*) (lemon sole)
J 28(9): 1241 (comparison of skin tumors in other flounder species)
T 216, 257 (taken in 1969 & 1970 B.C. & U.S. Pac. coast commercial trawling)
221 (catches during B.C. groundfish surveys)
246 (bibliography)
S 1487 (infection with *Philometra americana* nematode)

Sole, fantail (*Xystreurys liolepis*)
T 246 (bibliography)

Sole, flathead (*Hippoglossoides elassodon*)
J 28(9): 1241 (comparison of skin tumors in other flounder species)
T 210 (catches during B.C. groundfish surveys)
246 (bibliography)
257 (taken in 1970 B.C. trawl fishery)

Sole, gray (*see* Flounder, witch)

Sole, lemon (Pacific) (*see* Sole, English)

Sole, petrale (*Eopsetta jordani*) (Pacific brill)
J 28(5): 727 (salinity & temperature effects on embryonic development)
(10): 1672 (ambicoloration & anatomy of a)
T 210, 221, 269 (catches during B.C. groundfish surveys)
216, 257 (catches during B.C. & U.S. Pac. coast commercial trawling, 1969, 1970)
246 (bibliography)

Sole, rex (*Glyptocephalus zachirus*)
T 210, 221 (catches during B.C. groundfish surveys)
216, 257 (taken during B.C. & U.S. Pac. coast commercial trawling, 1969, 1970)
246 (bibliography)

Sole, rock (*Lepidopsetta bilineata*)
T 216, 257 (taken in 1969 & 1970 B.C. & U.S. Pac. coast commercial trawling)
220 (catches during B.C. groundfish surveys)
246 (bibliography)
259 (length & age composition of B.C., also commercial landings from Cape Scott Bank, 1959–1969)

Sole, sand (*Psettichthys melanostictus*)
J 28(9): 1241 (incidence of skin tumors, Bellingham Bay, Wash.)
T 246 (bibliography)
257 (taken in 1970 B.C. trawl fishery)

Sole, slender (*Lyopsetta exilis*)
J 28(10): 1563 (host of a new copepod species)
T 210, 221, 269 (catches during B.C. groundfish surveys)
246 (bibliography)
257 (taken in 1970 B.C. trawl fishery)

Sole, yellowfin (*Limanda aspera*)
T 246 (bibliography)
257 (taken in 1970 B.C. trawl fishery)

Somniosus microcephalus (*see* Shark, Greenland)

Sonstegard, R. A.
J 28(9): 1350 (infectious pancreatic necrosis of salmonids)

Sound, speed of (for general data re natural waters *see* Limnology; Oceanography. *See also* Echolocation; Sounding, echo; Ultrasonics)

Sound, ultrasonic (*see* Echolocation; Sounding, echo; Ultrasonics)

Sounding, echo (*see also* Echolocation)
J 28(3): 446 (electronic processing of acoustical data from fishery research)
(7): 1035 (quick statistical methods for analyzing digital echo fish counter sequences)
A 220 (bio-acoustical program during C.S.S. *Hudson* oceanographic survey circumnavigating N & S America)

Southcott, Burnett Anne
J 28(8): 1071 (salt tolerance of type E *Clostridium botulinum*)

Soviet Union (*see* Union of Soviet Socialistic Republics (USSR))

Sparks, Richard Edward
J 28(8): 1107 (computer simulation of pollution minnow deaths)

Spat (*see* Oyster, Atlantic; Oyster, Pacific)

Spawning
J 28(1): 98 (*Pandalus goniurus* shrimp)
(4): 513 (egg size re age of successive generations of Skeena R. sockeye salmon)
(4): 553 (meristic differences between spring- & autumn-spawning SW Nfld. herring)
(5): 727 (salinity & temperature effects re petrale sole embryonic development in B.C. coastal waters)
(6): 821 (escapement, re gillnet efficiency of Skeena R. sockeye & pink salmon fishery)
(6): 849 (beds: assessing silt characteristics by sampler)
(7): 935 (period re seasonal abundance of different fishes in communities, Passamaquoddy Bay, N.B.)
(7): 1009 (period, re S Gulf of St. Lawrence seasonal herring stocks discreteness)
(7): 1051 (season of white perch, Tomales Bay, Calif.)
(12): 1857 (kokanee transplanted into L. Huron)
B 178 (re raft-culturing of Pac. oyster in B.C.)
CJG 18: 25 (seasonal, of NE Nfld. & Labrador herring)
T 232 (razor clam, Queen Charlotte Is. & W coast Vancouver Is., B.C.)
252 (herring off southern N.S. coast)
S 1468 (behaviour of *Pacifastacus trowbridgii* crayfish)
1557 (temperature & photoperiod effects on crayfish subsequent)
1590 : 555 (of various fishes re temperature: review)
A 193 (Atl. & Pac. capelin)

Speciation; Subspeciation (*see also* Taxonomy)
J 28(1): 23 (*Calanus finmarchicus* vs. *C. glacialis*)
(3): 391 (*Mesodinium* ciliate species)
(4): 465 (lake char intraspecific variations & postglacial distribution)
(7): 987 (& subspeciation of *Salmo* in Upper Kern R. basin, Calif.)
(10): 1583 (possibilities of radioisotope X-ray fluorescence spectroscopy: review)
(10): 1403 (re amphipacific distribution of polychaetes)
(10): 1469 (re *Syllides* polychaetes)

Species, indicator (*see* Indicator species)

Species, introduced (*see also* Transplantation)
J 28(5): 663 (re rainbow trout worldwide distribution)
(12): 1857 (kokanee into L. Huron)
A 181 (summary of 1969 results of pink salmon transplants from B.C. to Nfld.)

Species, new (*see also* Genera)
J 28(5): 767 (*Labrifer balli*, trematode parasite of pink seaperch)
(10): 1373 (*Metavermilia annobonensis*, *M. taena*, & *M. nates* serpulid polychaetes)
(10): 1437 (*Dodecaceria berkeleyi*, cirrutulid polychaete from New Zealand)
(10): 1527 (*Pagurus caurinus*, *P. quaylei*, & *P. stevensae* hermit crabs, from B.C.)
(10): 1393 (*Stehnelais berkeleyi* sigalionid polychaete from E Pac.)
(10): 1483 (*Schroederella berkeleyi* polychaete from off Massachusetts)
(10): 1563 (*Holobomolochus venustus* & *H. occultus* parasitic copepods)
(10): 1429 (*Macellicephaloides berkeleyi* aphroditid polychaete, from Aleutian trench)
(10): 1615 (*Eualis berkeleyorum* caridean shrimp, off B.C. coast)
(10): 1469 (*Syllides benedicti* syllid polychaete)
(10): 1645 (*Rhabdochona canadensis* nematode parasitic in Albertan flathead chub, lake chub, & longnose dace)

(10): 1445 (*Magelona berkeleyi* polychaete, Puget Sound)
S 1488 (*Actiniscus canadensis*, new species; *A. pentasterias*, new variety *arcticus*; *Pseudoactiniscus apentasterias* new genus & species (dinoflagellates))
1496 (*Proclavellodes pillaii*, new genus & species of parasitic copepod, from S India)
1501 (*Hemibaphes intermedius* copepod parasitic on Strait of Georgia sculpins)
1533 (*Hesperophylax oreades* trichopteran, & *Cressoniella montana* (new genus) of Ephydridae in a high Colorado mountain creek)
1566 (parasitic copepod *Lernanthropus togatus* on gills of Kenyan marine fish *Gaterin*)
1577 (*Dinamoebidium coloradense* & *Katodinium auratum* dinoflagellates from Como Creek, Colorado)
1578 (*Dinamoebidium hyperboreum* from Ellesmere Is. coastal waters, N.W.T.)
1589 (*Dinoasteromonas tribrachiatus*, *D. pentaradiatus*, *D. deflanderi*, *D. brouweri* (flagellates))

Species, new records or range extensions of
J 28(3): 461 (Atlantic menhaden about 100 miles NE to Northumberland Strait)
(4): 616 (*Abraliopis felix* squid 300 miles N on Pac. coast)
(6): 927 (masked greenling, from Alaskan SE to B.C. coast)
(9): 1347 (bluespotted poacher 250 miles N into B.C.)
(9): 1349 (fifth known specimen of *Macdonaldia challengeri* spiny eel extends range to Oregon coast)
(10): 1527 (20 hermit crab species in or to B.C.)
(10): 1491 (*Chloeia entypa* & *Drilonereis falcata minor* polychaetes off Washington coast)
(10): 1563 (*Holobomolochus spinulus* parasitic copepod in Canadian waters)
(10): 1615 (*Parapasiphaë sulcatifrons*, *Acanthephyra curtirostris*, *A. quadrispinosa*, & *Systellaspis braueri* caridean shrimps off B.C. coast)
(10): 1469 (several Syllidae polychaete species)
(12): 1922 (first S extension of *Icelus Spiniger* sculpin to B.C. coast)
T 202 (diatoms new to Canadian Atl. provinces, from NW Miramichi R.)
225 (first NW Atl. record of *Yvesia* sp., *Plocamionida ambigua* & *Sphaerotylus borealis* (sponges))
S 1533 (1 genus, 3 species, & several forms, of chironomids new to N America, from a high Colorado mountain creek)

Species, relict
J 28(9): 1331 (zoogeographic problem re presence of relict *Pontoporeia affinis* amphipod in L. Washington, USA)
S 1488 (new genus, species, & variety of dinoflagellates in Canadian arctic lakes)

Speed of swimming (*see* Swimming)

Spence, John Andrew
J 28(1): 35 (differences in benthos caused by an impoundment)
(1): 45 (differences in fish populations caused by mainstream impoundment)

Sperm (*see also* Testes)
J 28(5): 745 (cryogenic preserved, for fertilizing coho & chinook salmon eggs)
(12): 1915 (cryogenic preserved, for fertilizing steelhead trout eggs)

Sphaeriidae
J 28(11): 1683 (associations & species diversification in L. Ontario bays)
S 1543 (of Georgian Bay, L. Ontario, & L. Erie)

Sphaerotylus (*see* Sponges)

Sphyrna lewini (*see* Hammerhead, scalloped)

Spinachia spinachia (*see* Sticklebacks)

Spindle shell (*Colus stimpsoni*) (Stimpson's whelk)
B 177 (re paralytic shellfish poisoning, E Canada)

Spine (*see* Fins; Vertebrae)

Spirochaete
S 1469 (*Cristispira* occurrence in 12 of 62 W Canada marine bivalve species)

Spisula solidissima (*see* Clam, bar)

Spleen
J 28(1): 47 (hemosiderin bodies re erythropoiesis in blue gourami)
(1): 112 (histology of cutthroat trout with leukemia condition)
(7): 1064 (vs. feces re presence of pancreatic necrosis virus in brook trout)

Spoilage (*see* Bacteria; Quality of fishery products; Trimethylamine)

Sponges
T 225 (associated with Bay of Fundy scallop beds, including first NW Atl. record for *Yvesia* sp., *Plocamionida ambigua*, & *Sphaerotylus borealis*)

Sport fishery (*see* Angling; Salmon; Trout)

Sprague, John Booty
J 28(1): 59 (DDT in Atl. fishes & shellfishes)
S 1510 (measurement of pollutant toxicity to fish)
1552 (decrease in DDT residues in young salmon)
A 223 (combating pollution on Canada's E coast)

Springs, thermal
J 28(1): 73 (ecological energetics & natural history of biota, also chemistry of waters, Mt. Rainier Nat. Park, USA)

Squalus acanthias (*see* Dogfish, spiny (Atlantic); Dogfish, spiny (Pacific))
suckleyi (*see* Dogfish, spiny (Pacific))

Squid (*Abraliopsis* (*Watasenia*) *felis*)
J 28(4): 620 (300-mile N range extension on Pac. coast, as identified by beak shape)

Squid, giant (*Architeuthis dux*)
S 1520 (*Hepatoxylon trichiuri* cestode from, Nfld., as clue to squid's feed)

Squid, longfinned (Atlantic) (*Loligo peali*)
T 199 (survey off U.S. Atl. coast, 1969)
S 1544(F) (previously reported northern range (Nfld.) reduced to N.S.)
1546 (NW Atl. resources & fisheries)

Squid, longfinned (Pacific) (*Loligo opalescens*)
T 257 (taken in 1970 B.C. trawl fishery)

Squid, shortfinned (*Illex illecebrosus*)
T 199 (survey off U.S. Atl. coast, 1969)
S 1546 (NW Atl. resources & fisheries)
A 181 (ICNAF Canadian 1969 research summary)
194 (Nfld. fishery)

Squids
J 28(4): 620 (300-mile N range extension on Pac. coast)
(11): 1796 (2 Pac. specimens of unusual type of gonatid; discussion of genera)
T 260 (standing crop, availability, weights, etc. from Scotian Shelf surveys, 1958–68)

Sreedharan, Ayyappan
T 256 (Georges Bank scallop meat sizes)

Srivastava, Vivien Mavis
T 261 (fish of Gulf of St. Lawrence)

St. Andrews, N.B.
J 28(1): 59 (DDT residues in marine shellfishes)

St. Clair, Lake (Ont. and Michigan)
J 28(8): 1133 (adult & juvenile walleye migrations through)

St. Lawrence, Gulf of (*see also* Oceanography, Atlantic Coast)
J 28(7): 1009 (discreteness of Atl. herring populations of spring & autumn fisheries in S)
B 177 (paralytic shellfish toxicity in)
T 204 (tagging & movements of male queen crabs)
261 (bibliography for 145 fishes)
271 (circulation patterns, June 1968 & Sept. 1969)
S 1464 (critique of aging herring by otoliths)
A 199 (marine geological investigations of sediments)

St. Margaret's Bay, N.S.
J 28(7): 971 (ecological production & mathematical model of population for *Sagitta elegans* chaetognath)
(11): 1733 (production potential of seaweed–lobster community)
T 219 (physical oceanography)
252 (herring larvae ecology)
S 1482 (comparison with eutrophicated Bedford Basin, N.S.)
1539 (capacity to accept pollutants)
1579 (phytoplankton annual production)

St. Mary's Bay (*see* Placentia Bay, Nfld.)

St. Pierre, Lac, Que.
J 28(5): 786 (heavy-metal concentrations in dressed northern pike)

Stainton, Michael Paul
J 28(2): 277 (surface sediment chemistry of FRB Experimental Lakes, NW Ont.)
S 1534 (mercury vapor for atomic absorption)
A 178 (determination of residual mercury in fish tissue)

Staleness (*see* Quality of fishery products)

Stamina (*see* Stress)

Starfish, common (*Asterias forbesi*) (*see also* following heading)
J 28(9): 1225 (cadmium toxicity tests)

Starfish, common (*Asterias vulgaris*) (*see also* preceding heading)
J 28(5): 793 (yellow phosphorus concentration by, N.S.)
(9): 1285 (methylmercury in, off N.S.)
T 217 (pollution from petroleum oil spills)
S 1569 (determination of residual fuel oil contamination in)

Starfishes (Asteroidea; Ophiuroidea)
T 225 (associated with Bay of Fundy scallop beds)

Starvation
J 28(4): 587 (effects on rainbow trout metabolism)
(11): 1757 (response of young sockeye salmon after)

Statistical treatment of data (*see* Mathematical treatment of data)

Steaks, fish
J 28(7): 1061 (practical small-scale commercial dryer)
A 203 (precooked in batter)

Steele, Donald Harold
J 28(8): 1153 (Nfld. winter flounder)

Stehnelais (sigalionid Polychaeta)
J 28(10): 1393 (*S. fusca* & new species *S. berkeleyi* from E Pac.)

Stein, David
J 28(9): 1349 (notacanthid collected off Oregon coast)

Stephens, Kenneth Valentine Cory
S 1467 (dissolved nutrients automated measurement)
1504 (continuous measurement of turbidity)

Steroids; Sterones (*see also* Cortisol; Hormones)
J 28(4): 477, 485 (histological effects on tissues of gonadectomized sockeye salmon)
S 1477 (identification & distribution of steroid-producing Ledig cell homolog in Atl. salmon testis)
1478, 1479 (interrenal histology & steroidogenesis in Atl. strugeon)
1489 (blood proteins binding affinities for corticosteroids in 3 Alt. fishes)
1576 (corticosteroids & testosterone in Atl. sturgeon plasma)
A 214 (corticosterone sex hormones to accelerate maturation in fish farming)

Sterols; Sterol esters (*see also* Cortisol; Hormones)
J 28(4): 477, 485 (histological effects on tissues of gonadectomized sockeye salmon)
(4): 606 (cholesterol content of juvenile coho salmon blood)
(10): 1675 (of *Terebratalia transversa* brachiopod)
S 1457 (desmosterol, cholesterol & minor sterols content of dulse & 3 other red seaweeds)
1459 (new sterol type (C_{26}) isolated from sea scallop)
1506 (identification of various sea scallop muscle)
1527 (of 14 crustacean species)

Stevenson, James Cameron
J 28(2): 121 (foreword)
(10): 1360 (Edith & Cyril Berkeley — An appreciation)
B 177 (preface)

Stewart, James Edward
CHN 40 (gaffkemia & storage temperatures re red crab)
41 (gaffkemia among stored lobsters)
42 (gaffkemia control in lobster storage facilities)
A 180 (gaffkemia of lobsters)

Stichaeus punctatus (*see* Shanny, arctic)

Stickland, John Allan
T 253 (velocity and water temperature records, Strait of Georgia)

Stickleback, blackspotted (*Gasterosteus wheatlandi*) (two-spine stickleback)
J 28(3): 427 (phylogeny, diagnostic features & range)
T 261 (bibliography for Gulf of St. Lawrence)

Stickleback, brook (*Culaea* (*Eucalia*) *inconstans*)
J 28(3): 427 (phylogeny, diagnostic features, & range)
(6): 919 (temperature & light effects on pre-spawning)

Stickleback, fourspine (*Apeltes quadracus*)
J 28(3): 427 (phylogeny, diagnostic features, & range)
T 261 (bibliography for Gulf of St. Lawrence)

Stickleback, ninespine (*Pungitius pungitius*)
J 28(3): 427 (phylogeny, diagnostic features, & range)
T 261 (bibliography for Gulf of St. Lawrence)

Stickleback, threespine (*Gasterosteus aculeatus*)
J 28(3): 427 (phylogeny, diagnostic features, & range)
(7): 999 (schooling vs. aggregation spacing & density)
(10): 1563 (new host of *Bomolochus cuneatus* copepod)
T 261 (bibliography for Gulf of St. Lawrence)

Stickleback, twospine (*see* Stickleback, blackspotted)

Sticklebacks
J 28(3): 427 (osteology re phylogenetic relations to tube-snouts; *Spinachia spinachia* diagnostic features & range)

Stingray, roughtail (*Dasyatis centroura*)
T 261 (bibliography for Gulf of St. Lawrence)

Stipe
J 28(5): 778 (length & presence of cavity re taxonomy of *Laminaria* seaweeds)

Stizostedion canadense (*see* Sauger)
vitreum vitreum (*see* Walleye)

Stock; Standing stock (*see also* Abundance; Fisheries; Mortality; Populations; Recruitment; *also* names of organisms)
J 28(2): 215 (of periphyton in 4 small NW Ont. lakes)
(7): 1009 (discrete spring & autumn, in S Gulf of St. Lawrence herring fishery)
CJG 18: 1 (Nfld. herring)
T 246 (bibliography of N America Pac. coast trawl fishery)
256 (Georges Bank scallops)
248 (zooplankton, re marine productivity)
S 1513 (zooplankton, re marine productivity)
1540 (Atl. cod; ICNAF Subareas 2 & 3)
1546 (probable underexploitation of NW Atl. squids)

A 206 (ICNAF 1970–72 forecast for haddock)

Stocking
J 28(5): 663 (re worldwide introduction of rainbow trout)

Stockner, John Gary
J 28(1): 73 (*Hedriodiscus truquii* (Diptera) energetics & history)
(2): 215 (periphyton in FRB Experimental Lakes, NW Ont.)
(2): 265 (diatoms in FRB Experimental Lakes, NW Ont.)

Stomach (*see also* Digestion; Feed)
J 28(4): 485 (histological effects of hormones & cortisol on gonadectomized adult sockeye salmon)
B 177 (paralytic shellfish toxin in E Canada scallops)

Stomach contents (*see* Digestion; Feed)

Stoneflies (Plecoptera) (*see also* Insects, aquatic)
J 28(6): 849 (samplings from shallow stream beds)
S 1532, 1533 (of a high Colorado mountain creek)

Stones, "holed" (*see* Geology)

Storage (*see also* Chilling; Holding; Ice; Refrigeration; Sea water, refrigerated)
CHN 40 (recommended red crab live storage temperatures)
T 242 (harmful effects of mishandling on quality of sockeye salmon stored at sea for canning)

Strait of... (*see* name of strait)

Strasdine, George Alfred
J 28(11): 1817 (phosphatase activity in *Clostridium botulinum* spores and cells)
S 1585 (amylopectin accumulation in *Clostridium botulinum* type E)

Streams & stream beds (*see* Benthos; Limnology; Sampling; Sediments; Spawning)

Stress; Fatigue; Stamina (*see also* Activity; Handling; *also* other stress causes)
J 28(4): 527 (osmotic, in ribbed mussel re upper lethal temperatures)
(7): 1064 (effect of, in detecting masked bacterial & viral infections in fish)
(8): 1215 (changes in blood lactic acid concentration of alewives passing through fishway)
(12): 1899 (from formalin disinfection of young salmonids)

Strickland, John Douglas Hipwell
J 28(4): 599 (obituary of)

Strongylocentrotus (*see* Sea urchin)

Strontium derivatives
S 1529 (distribution in L. Ontario)
A 232 (^{90}Sr as radioactive marine pollutant)

Sturgeon, Atlantic (*Acipenser oxyrhynchus*)
T 261 (bibliography for Gulf of St. Lawrence)
S 1478, 1479 (interrenal histology & steroidogenesis studies)
1576 (plasma corticosteroids & testosterone)

Sturgeon, green (*Acipenser medirostris*)
T 257 (in B.C. & U.S. Pac. coast commercial trawling, 1970)

Sturgeon, lake (*Acipenser fulvescens*)
T 261 (bibliography for Gulf of St. Lawrence)
A 201 (mercury contamination, Great Lakes)

SubbaRao, Durvasula Venkata
S 1538 (marine energy flow)

Subspeciation (*see* Speciation)

Sucker, largescale (*Catostomus macrocheilus*)
J 28(4): 533 (*columnaris* disease re fish ladders)

Sucker, longnose (*Catostomus catostomus*)
J 28(1): 45 (populations upstream & downstream of a dammed Ont. lake)
(1): 105 (DDT residues in muscle, of Saskatchewan R.)
(11): 1745 (biochemical & cytological study)
T 261 (bibliography for Gulf of St. Lawrence)
A 200, 201 (mercury contamination in Canadian waters)

Sucker, white (*Catostomus commersoni*)
J 28(1): 105 (DDT residues in muscle, of Saskatchewan R.)
(7): 957 (vulnerability to northern pike predation)
(7): 1061 (practical drying equipment for fillets & steaks; proximate analysis of dried steaks)
(9): 1325 (postmortem changes in muscle glycogen phosphorylase activity)
(11): 1745 (biochemical & cytological study of large & dwarf forms)
T 226 (mortalities from *Aeromonas liquefaciens* disease in NW Miramichi R., N.B.)
261 (bibliography for Gulf of St. Lawrence)

Sugars; Sugar derivatives (*see also* Glucan; Glucose; Saccharides)
J 28(8): 1173 (hexose, hexosamine, & fucose levels in Pac. salmons, trouts, & bovine blood sera)

Sulphate (for general data re natural waters, *see* Limnology; Oceanography)

Sulphides
T 245 (hydrogen sulphide possible natural cause of multispecies mortality in tidal Nitinat L., B.C.)
255 (sodium sulphide toxicity tests on brook trout)
S 1500 (principal pollutant gas from B.C. coastal water sediments close to pulpmills; formation from sediments by *Desulfovibrio desulfuricans*)
1561 (sulphydryl content of rabbit & rainbow trout myosins re protein stability)

Sulphite (*see also* Pollution; Pulp mill effluents)
T 255 (toxicity tests on brook trout)

Sunde, Leif Axel
T 165(F) (central Canada rainbow trout farming)

Sunfish, bluegill (*see* Bluegill)

Sunfish, green (*Lepomis cyanellus*)
J 28(4): 610 (dieldrin pesticide concentration in blood & brain)
(7): 957 (vulnerability to northern pike predation)
(11): 1811 (alkali tolerance in Nebraska eutrophic lakes & ponds)

Sunfish, ocean (*Mola mola*)
J 28(3): 323 (morphology of *Lepeophtheirus* copepod parasites)
T 261 (bibliography for Gulf of St. Lawrence)

Sunfish, redbreast (*Lepomis auritus*)
J 28(9): 1285 (methylmercury in N.B.)

Superchilling; Supercooling (*see also* Chilling)
J 28(5): 745; (12): 1915 (cryo-preserved sperm for fertilizing salmonid eggs)
(8): 1217 (re ultrasonic method for distinguishing thawed frozen fish from fresh fish)
T 242 (effects of storing sockeye salmon in refrigerated sea water re quality of canned product)
S 1590 : 533 (survival of fishes after supercooling: review)
A 203 (resume of T 242 above)

Superior, Lake (*see also* Great Lakes)
J 28(1): 65 (lake trout population biology before lamprey invasion)
(5): 771 (rainbow trout life history, Batchawana Bay)

Surgery
J 28(5): 635 (physiological effects on brook trout)

Surveys (*see also* names of International Commissions)
T 199 (otter-trawl catches, U.S. Atl. coast, 1969: over 100 species; not individually indexed)
210, 221, 269 (observations during groundfish trawling cruises off B.C. & Washington coasts, 1970–71)
213 (observations during B.C. herring surveys, 1969)
225 (fauna associated with sea scallops in dredging surveys, Bay of Fundy)
246 (bibliography of N America Pac. coast trawl fishing)
A 184 (aerial, of harp seal, & general, of ringed seal, in Canadian Arctic)
204 (origin of N Pac. Ocean salmons & steelhead trout)
206 (re haddock)
207, 219 (Atl. herring egg distribution & abundance)
220 (C.S.S. *Hudson* oceanographic cruise circumnavigating N & S America)

Survival (*see also* Lethal limits; Mortality; Pollution; Tolerance)
J 28(3): 335 (of bacteria ingested by tubificid oligochaetes)
(3): 343 (salinity effects on pre-smolt coho salmon)
(4): 465 (lake char during Pleistocene glaciation in N America)
(4): 527 (of ribbed mussels during low-tide exposures)
(5): 647 (pink salmon eggs transplanted to Qualicum R., B.C.)
(6): 924 (temperature requirements for larval lake cisco)
(7): 1057 (larval & young fish in warm discharge canal of nuclear power plant)
(8): 1119 (low oxygen concentration effects on fathead minnow fry)
(11): 1811 (freshwater fishes in alkaline eutrophic Nebraska lakes & ponds)
S 1590 : 533 (of fishes after supercooling; review)
A 184 (harp seal in Canadian Arctic)

Susquehanna River, Pennsylvania and Maryland
J 28(6): 911 (contribution of particulate carbon & nitrogen to Chesapeake Bay, Md.)

Sutterlin, Arnold Martin
J 28(4): 491 (hypoxic responses in the sea raven)
(4): 565 (olfactory epithelial responses)
S 1550 (proprioceptors in gills of teleosts)

Sutterlin, Natalie
J 28(4): 565 (olfactory epithelial responses)

Swimmers' itch
A 58(F) (cause, control, & treatment)

Swimming; Swimming speed
J 28(4): 587 (rainbow trout speed re metabolism)
(8): 1143 (parasitic copepods locomotory mechanisms)
S 1590 : 548 (speed, of various fishes re temperature; review)

Swordfish (*Xiphias gladius*)
J 28(1): 31 (cestode & trematode parasites in N Atl.)
(7): 947 (blood pathways effects on blood-pressure drop in gills)
T 261 (bibliography for Gulf of St. Lawrence)
273 (halogenated hydrocarbon residues detected in)
A 182 (ICNAF Canadian 1969 research summary)

Sydney Harbour, N.S.
S 1584 (herring mortality from coke-oven intermediate oil pollution in N)

Syllides (*see also* Polychaeta)
J 28(10): 1469 (new species *Syllides benedicti*, descriptions of 6 other species, & key to genus)
(10): 1459 (seasonal settlement on test panels)

Symbionts
J 28(3): 391 (incomplete, of red-water ciliate *Mesodinium rubrum*)

Symons, Philip Edward Kyrle
J 28(7): 999 (spacing in schooling fish)
(11): 1805 (estimating distances in schooling aquarium fish)
S 1555 (claw-shuddering behaviour of shore crab)

Sympatry
J 28(9): 1259 (vs. allopatry re feed & habits of Dolly Varden & cutthroat trouts in 3 B.C. lakes)
S 1547 (brown & brook trout ecology in a Nfld. stream)

Syngnathus fuscus (*see* Pipefish, northern)

Synonymy (*see* Nomenclature; Taxonomy)

Syrett, Roll Frederick
J 28(6): 924 (temperature requirements for larval ciscos)

Syringe
S 1534 (for transferring mercury vapour in mercury assays)

Systellaspis (caridean shrimps)
J 28(10): 1615 (*S. braueri* new record, off B.C. coast)

Systematics (*see* Genera; Keys; Nomenclature; Phylogeny; Speciation; Species; Taxonomy)

T

Tabata, Susumu
T 253 (velocity & water temperature records, Strait of Georgia)

Tadpole, sea (*Careproctus reinhardi*)
T 261 (bibliography for Gulf of St. Lawrence)

Tagging methods, returns, losses, and interpretation (*see also* Marking; Migration; for "biological tags" *see* Indicator species)
J 28(1): 49 (salamanders with toe clips)
(3): 351 (Miramichi R., N.B., salmon to ascertain relative utilization rates by angling vs. maritime commercial fisheries)
(3): 369 (multivariant analysis of X-ray spectroscopic chemical element composition as "natural tag")
(3): 383 (re homing of tidepool sculpin)
(4): 537 (jaw tagging effects on landlocked Atl. salmon growth & scale characteristics)
(8): 1133 (adult & juvenile walleye re migrations between L. Huron & L. Erie)
(10): 1583 (possibilities of radioisotope X-ray fluorescence spectrometry: review)
CJG 18: 20 (herring: results in SW Nfld. waters)
T 204 (male queen crabs, Gaspe region of Gulf of St. Lawrence)
246 (bibliography of N America Pac. coast trawled fishes)
250 (computer programming history data)
S 1492 (haddock movements off Digby, N.S.)
1581 (harp seal)
A 192 (Atl. salmon off Greenland)
204 (Pac. salmons & steelhead trout during INPFC studies, 1965)

Tail
J 28(1): 95 (differential growth in big skate embryos, re respiration mode)

Tanks (*see also* Aquaria)
J 28(8): 1196 (digital recorder monitoring of dissolved oxygen in)
CHN 42 (disinfecting lobster-holding, against gaffkemia lobster disease bacteria)
T 243 (sablefish culture)

Tapeworms (*see* Cestoda)

Tapirfish, largescale (*see* Eel, spiny)

Tardigrada
S 1532 (of a high Colorado mountain creek)

Taricha granulosa (*see* Newt)

Tarr, Hugh Lewis Aubrey
J 28(10): 1603 (ribonucleotide reductase in salmon testes)
S 1523 (fish muscle phosphorylases)
1525 (fish liver enzymes)
1560 (deoxyribonucleic acid polymerase from salmon testes)
A 203 (seafood sanitation and quality)
218 (fisheries research)

Taste panels (*see* Quality of fishery products)

Tautogolabrus adspersus (*see* Cunner)

Taxonomy; Synonymy; Systematics (*see also* Family; Genera; Keys; Nomenclature; Phylogeny; Speciation)
J 28(1): 23 (status of adult male *Calanus finmarchicus* re *C. glacialis* copepods)
(3): 323 (*Lepeophtheirus* vs. *Dentigryps* parasitic caligid copepods)
(3): 391 (red-water *Mesodinium* ciliates, & key)
(3): 427 (osteology of tube-snouts & sticklebacks re their phylogeny & speciation)
(4): 517 (*Vibrio anguillarum* bacterium; correction on J 28(8): 1219)
(5): 778 (*Laminaria* seaweeds re stipe length & environment)
(7): 987 (western N America *Salmo* species & subspecies)
(10): 1373 (revision of *Metavermilia* serpulid polychaetes)
(10): 1583 (possibilities of radioisotope X-ray fluorescent spectrometric analysis: review)
(10): 1595 (arguments for classifying *Velella* as hydroids)
(10): 1621 (northern rockfish)
(10): 1645 (*Rhabdochona* parasitic nematode species in N & central America)
(11): 1796 (need for redefinition of gonatid squid family)
T 200 (possibilities of X-ray fluorescence spectrophotometry of elemental composition of organisms re their classification)
231 (arctic chars)
S 1499 (caligid copepod *Caligus rapax*)
1533 (chironomids in a high mountain brook, Colorado)
1588 (*Harnischia* chironomids)
1589 (fossil & contemporary Dinophyta secreting discoasters)

Taylor, Frank John Rupert
J 28(3): 391 (red-water ciliate *Mesodinium rubrum*)

Taylor, Frederick Henry Carlyle
J 28(10): 1663 (recorded distribution of herring from seal stomachs)
T 213 (1969–70 B.C. offshore herring survey)

Teeth
J 28(9): 1309 (formation & use for aging, in white whale)
A 229 (aging whales & other mammals by layered structure of: book review)

Temora longicornis (*see* Copepoda)

Temperature (*see also* Temperature, reactions to) (*Note*: The numerous data for temperature of natural waters routine observations are not indexed unless having special significance. *See* Limnology; Oceanography)
J 28(1): 100 (plotting bathythermograph transect data on a computer printer)
T 219 (regime in waters of St. Margaret's Bay N.S.)
253 (observations from moored instruments, with examples of records, Strait of Georgia, 1968–70)
S 1461 (thermistor readout monitoring system for cold storage temperatures)
1542 (& salinities in E Nfld. waters)
A 204 (N Pac. Ocean surface, 1950–1965)

Temperature, reactions to and effects of
J 28(4): 527 (upper lethal temperatures re osmotic stress in ribbed mussel)
(4): 587 (re rainbow trout active & standard metabolism)
(5): 727 (re petrale sole embryonic development)
(6): 883 (effects on Pac. cod eggs development re geographical distribution)
(6): 919 (prespawning brook sticklebacks, Roseau R., Man.)
(6): 924 (re larval lake cisco growth & survival)
(7): 935 (effects on seasonal components of fish communities in Passamaquoddy Bay, N.B., & in warmer waters)
(7): 971 (re *Sagitta elegans* chaetognath life history, St. Margaret's Bay, N.S.)
(7): 1057 (mortality vs. survival of larval & young fish in warm water of nuclear power plant discharge canal)
(10): 1545 (effects on Pac. herring early development)
(10): 1459 (re polychaetes settlement on test panels)
(11): 1739 (young rainbow trout & chinook salmon re *columnar* disease susceptibility)
(11): 1801 (rainbow trout fingerlings preferences in horizontal & vertical temperature gradients)
CHN 40 (recommended red crab live storage temperatures)
T 231 (re arctic char in a small arctic lake)
236 (re mud dab egg & larvae development)
243 (tank-cultured sablefish)
262 (ecological problems re hot effluent water from steam-electric power plants)
S 1556 (effects on Atl. salmon & brook trout brain tissue oxygen consumption)
1557 (effects on crayfish ovarian maturation & egg laying)

1590 (habitat temperature re body temperature of fishes: review)
A 222 (acclimation to, by salmonids, as affected by DDT pollutant)

Templeman, Wilfred
T 160 (additional data on Atl. *Lepidion*)
192 (additional data on characteristics of Greenland halibut)
S 1542 (eastern Nfld. area temperatures and salinities)
A 181 (reports on researches in ICNAF area, 1969)

Tennant, Alan Dawson
B 177 (E Canada paralytic shellfish poisoning)

Tentacles
J 28(10): 1595 (concert behaviour of *Velella*)

Terebratalia (*see* Brachiopoda)
J 28(10): 1675 (*T. transversa* sterols)

T 225 (*T. septentrionalis* associated with Bay of Fundy scallop beds)
268 (*T. transversa*, *T. crossei*, & *T. unguicula* in B.C. faunistic surveys since 1960)

Terhune, Lorne Donald Bruce
J 28(7): 1062 (detecting burrowed lobster)

Territorialism (*see* Aggression; Behaviour; Spawning)

Testes (*see also* Hermaphroditism; Hormones; Maturity; Reproduction; Sperm)
J 28(4): 477, 485 (hormones effects on gonadectomized sockeye salmon)
(8): 1191 (fatty acids & amino acids of Dungeness crab)
(10): 1603 (ribonucleotide reductase in immature sockeye salmon)
S 1477 (identification & distribution of Leydig cell homolog in sexually mature Atl. salmon)
1508 (purification & properties of acid deoxyribonuclease from chinook salmon)
1560 (deoxyribonucleic acid polymerase from sockeye salmon)
1562 (major hormones in plasma of sexually maturing Atl. salmon)

Testosterone and derivatives (*see* Hormones)

Tetrapturus audax (*see* Marlin, striped)

Texture (of flesh) (*see* Firmness; Quality of fishery products)

Thais lapillus (*see* Dogwinkle, Atlantic)

Thaleichthys pacificus (*see* Eulachon)

Thawing
J 28(8): 1217 (distinguishing thawed frozen fish from fresh fish)

Theragra chalcogramma (*see* Pollock, walleye)

Thermal power plants (*see also* Nuclear Power plants)
T 262 (ecological problems re effluent disposal from steam-electric plants)

Thermocline (*Note:* The numerous data for thermoclines in natural waters routine observations are not indexed unless having special significance. *See* Limnology; Oceanography; Temperature)
J 28(2): 163 (in numerous small NW Ont. lakes)

Thermocouple (*see* Thermostat)

Thermograph (*see* Apparatus; Bathythermograph; Limnology; Oceanography; Temperature)

Thermostat; Thermocouple
S 1461 (thermistor readout monitoring system for cold storage temperatures)

Thlewiaza River, N.W.T.
S 1573 (occurrence of harbour seals in upper lakes of)

Thomas, Martin Lewis Hall
S 1580 (classification of P.E.I. benthic samples)
A 109(F) (control of eelgrass by 2,4-D)

Thomson, John Arthur Collingwood
T 212 (IBM programs for multiple discrimination analysis)
230 (Pac. Ocean transport charts, 1969)
237 (weight–length relationship for Pac. ocean perch)
238 (N Pac. Ocean transport computations, 1970)
239 (N Pac. Ocean transport computations, 1969)
240 (N Pac. Ocean transport charts, 1970)

Thorne, Richard Eugene
J 28(9): 1269 (investigations re echo voltage and fish density)
(9): 1275 (estimation of hake population by echo integrator)

Thornyhead, longspine (*Sebastolobus altivelis*) (longspine channel rockfish)
T 246 (bibliography)

Thornyhead, shortspine (*Sebastolobus alascanus*) (shortspine channel rockfish; spinycheeked rockfish)
T 221 (catches during B.C. groundfish surveys)
246 (bibliography)
257 (taken in B.C. trawl fishery, 1970)

Thunnus alalunga (*see* Albacore)
albacares (*see* Tuna, yellowfin)
obesus (*see* Tuna, bigeye)
thynnus (*see* Tuna, bluefin)

Thymallus arcticus (*see* Grayling, arctic)

Thyroid gland
J 28(4): 477 (histological effects of hormones & cortisol on gonadectomized sockeye salmon)

Thysanoëssa (*see* Euphausiids)

Tibbo, Simeon Noel
J 28(7): 1009 (Atl. herring populations)
S 1464 (use of otoliths for aging herring)
1584 (fish kill from coke-oven oil)
A 207 (Atl. herring fisheries)

Tides (*see also* Currents; Oceanography)
T 219 (St. Margaret's Bay, N.S.)
S 1539 (re capacity of estuaries to accept pollutants; use of dyes to follow flushing action)

Tilapia (*Tilapia mossambica*)
J 28(9): 1342 (measuring CO_2 production & respiratory quotient)

Tin derivatives
J 28(5): 786 (in dressed Canadian fishes from industrial area lakes)

Titanium derivatives
J 28(2): 277 (in sediments of 13 small NW Ont. lakes)

Tocopherol
S 1480 (composition of *Porphyridium cruentum* unicellular red alga)

Todd, Ian St. Pierre
J 28(6): 821 (gillnet selectivity on sockeye & pink Skeena R. salmon)

Tolerance (*see also* Lethal limits; *also* factors involving tolerance reactions, e.g. Oxygen, dissolved; Pollution; Salinity, reactions to; Survival; Temperature, reactions to)
J 28(8): 1071 (*Clostridium botulinum* to sodium chloride)
(9): 1327 (of copepods to particulate oil from fuel oil marine spills)
(10): 1545 (Pac. herring eggs & early larvae to temperature & salinity combinations)
(11): 1811 (of freshwater fishes to alkalinity in eutrophic Nebraska lakes & ponds)
B 177 (human, to paralytic shellfish poison)
T 202 (river diatoms towards heavy-metal pollution)
S 1590 : 518 (fishes to environmental temperature; review)

Tomales Bay, California
J 28(7): 1051 (white seaperch maturity & fecundity)

Tomcod, Atlantic (*Microgadus tomcod*)
J 28(1): 59 (DDT residues in N.B.)
(7): 935 (occasional component of Passamaquoddy Bay fish communities, N.B.)
T 261 (bibliography for Gulf of St. Lawrence)

Tomcod, Pacific (*Microgadus proximus*)
T 246 (bibliography)
257 (taken in 1970 B.C. trawl fishery)

Tomlinson, Neil
T 220, 242 (storage of Pac. salmon at sea)

Tooth (*see* Teeth)

Torpedo californica (*see* Ray, Pacific electric)

Towers, George Hugh Neil
S 1491 (fission of phenylalanine by marine algae)

Toxicants; Toxicity (*see also* Insecticides; Pesticides; Piscicides; Pollution; *also* names of toxic elements)
J 28(1): 59 (levels of DDT residues in some Atl. coast food fishes & shellfishes)
(8): 1071 (sodium chloride effects on *Clostridium botulinum* toxin production in Pac. cod flesh homogenates)
(11): 1789 (melanin distribution in butter clam re retention of paralytic shellfish toxin)
B 177 (paralytic shellfish toxin: nature; anatomical distribution; assay method)
T 217 (petroleum oil characterization re tracing origin of fuel oil spills affecting aquatic environments)
218 (antibacterial effects of sea water)
255 (yellow phosphorus production wastes, e.g., phosphorus, fluosilicic acid, cyanide, etc. to fishes)
258 (trisodium nitrilotriacetate as replacement for phosphate detergents: tests on aquatic life)
272 (halogenated hydrocarbons to fishes & birds)
S 1484 (molecular structure of halogenated mononitrophenols re piscicide activity)
1510 (applying bioassay results to pollutant toxicities towards fish: review)
1558, 1570 (polychlorinated biphenyls in sea water to *Gammarus oceanicus* amphipod)
A 201 (*Botulinus* toxin transmitted from fishes to their predators)
203 (developed by fish-spoiling organisms)

Toxins (*see* Toxicants)

Trace elements (*see* Pollution; *also* names of elements) Composition, chemical; Nutrients (aquatic);

Tracking (*see also* Echolocation; Marking; Migration; Sounding, echo; Tagging)
S 1539 (currents with dyes, re ability to flush away pollutants)
1581 (harp seals)
A 184 (harp seals)

Transferases (*see* Enzymes; Genetics)

Translation indexes
T 246 (bibliography re N America Pac. coast trawled fishes)

Transparency of natural waters (*see also* Limnology; Oceanography; Radiation, solar; Turbidity)
J 28(2): 129, 157, 231 (small lakes in NW Ont.)
T 265 (Frobisher Bay, Baffin Is., N.W.T.)

Transplantation (*see also* Species, introduced)
J 28(5): 647 (results for 3 generations from pink salmon eggs, from B.C. mainland to Vancouver Is.)
(7): 1019 (role of social behaviour when hatchery rainbow trout released into a stream)
(12): 1857 (B.C. & U.S. kokanee into L. Huron)
A 181 (research summary on success of B.C. pink salmon, to Nfld.)
209 (sea otters from Alaska to B.C.)

Transport, mass (of waters) (*see also* Currents, marine; Oceanography)
T 230, 240 (N Pac. Ocean Ekman transport charts 1969, 1970)
238, 239 (N Pac. Ocean Ekman & other transport calculations, 1970, 1969)

Transportation
A 203 (fish to processing plants, including frozen fish by air)

Trap; Pot
J 28(8): 1209 (2 simple durable collectors for epifauna)
S 1518 (for prawns)
A 128(F) (experimental prawn trap fishing, B.C.)

Trawling; Trawls
J 28(10): 1615 (B.C. coastal surveys resulting in 1 new species & 4 new B.C. records of caridean shrimps)
T 199 (otter-trawl survey catches, U.S. Atl. coast, 1969)
210, 221, 269 (groundfish surveys off B.C. & Washington coasts, 1970–71)
216, 257 (summary of B.C. & U.S. Pac. coast commercial fishery, 1969, 1970)
246 (bibliography of fishery & groundfish, N American Pac. coast)
260 (catch availability & 1958–68 surveys data, groundfish on Scotian Shelf)
S 1493 (assessment of effects of Atl. cod nets mesh size increases)
1540 (cod catches per unit effort in ICNAF Subareas 2 & 3)
1541 (American plaice catches per unit effort in ICNAF Subarea 3)

Traxler, Garth Stanley
J 28(1): 104 (skin lesions of rainbow trout)

Trematoda (*see* Flukes)

Tretiak, Daniel Nicholas
J 28(7): 1005 (walleye malate dehydrogenase)

Triaenophorus (*see* Cestoda)

Trichodon trichodon (*see* Sandfish, Pacific)

Trichogaster trichopterus (*see* Gourami, blue)

Trichoptera (*see* Caddisflies)

Triclad (*see* Turbellaria)

Triglops murrayi (*see* Sculpin, moustache)
pingeli (*see* Sculpin, ribbed)

Triglycerides (*see* Glycerides; Lipids; Oils and fats)

Trimethylamine (TMA) (*see also* Amines; Dimethylamine)
J 28(1): 1 (possible precursor of dimethylamine in stored frozen fish muscle)
(3): 305 (production from TMA oxide by bacteria in chilled haddock fillets)

Trimethylamine oxide (*see* Trimethylamine)

Trites, Ronald Wilmot
T 219 (physical oceanography of St. Margaret's Bay)
271 (Gulf of St. Lawrence circulation patterns)
S 1539 (capacity of an estuary to accept pollutants)

Tritium (*see* Hydrogen)

Tropocyclops (*see* Copepoda)

Trout, Apache
J 28(7): 987 (probable ancestry; meristic characters re western N America *Salmo*)

Trout, brook (*Salvelinus fontinalis* (speckled trout)
J 28(1): 100 (device for rapidly removing embryos from eggs)
(3): 452 (world distribution; native & introduced)
(3): 458 (response of populations to a fishery)
(4): 509 (skin & flesh colour enhancement when fed shrimp & crab wastes plus carotenoid)
(5): 625, 635 (physiological effects of handling, tricaine methane sulphonate anesthetization, & surgery)
(5): 655 (long-term effects of copper sulphate concentrations on adults, eggs, & fry)
(6): 801 (re fish growth efficiency analysis)
(7): 1064 (infectious pancreatic necrosis virus in feces vs. organs; effect of stress)
(8): 1113 (calorie-to-protein ratio of rations re energy requirements)
(9): 1285 (methylmercury in N.B.)
T 255 (toxicity tests with yellow phosphorus production wastes)
261 (bibliography for Gulf of St. Lawrence)
S 1547 (ecological interactions with brown trout in a Nfld. stream)
1556 (temperature effects on brain tissue oxygen consumption)
A 222 (pollutants effects on physiology & behaviour)

Trout, brown (*Salmo trutta*)
J 28(9): 1285 (trimethyl mercury in N.B.)
S 1545 (electrophoretic analysis of protein & esterase systems of hybrids with Atl. salmon)
1547 (ecological interactions with brook trout in a Nfld. stream)

Trout, coastal cutthroat (*Salmo clarki clarki*)
J 28(7): 987 (re systematics & evolution of western N America *Salmo*)
S 1563 (& rainbow trout, re multiple hemoglobins subunit structures & molecular basis)

Trout, cutthroat (*Salmo clarki*)
J 28(1): 112 (leukemia manifestations in)
(7): 987 (meristic characters re systematics & evolution of western N America *Salmo*)
(8): 1173 (glycoproteins constituents levels in blood sera)
(9): 1259 (sympatry & allopatry with Dolly Varden, re feed & habits in 3 B.C. lakes)

Trout, Dolly Varden (*see* Dolly Varden)

Trout, golden (*Salmo aguabonito aguabonito*) (*Salmo mykiss aguabonito*; *Salmo "roosevelti"*)
J 28(7): 987 (meristic characters in Kern R. Basin, Calif., re systematics & evolution of western N America *Salmo*; also hybridization)

Trout, Heenan Lake (*Salmo clarki henshawi*)
J 28(7): 987 (re systematics & evolution of western N America *Salmo*)

Trout, Kern River (*Salmo aguabonito gilberti*) (*Salmo gairdneri gilberti*; *Salmo whitei*)
J 28(7): 987 (meristic characters in Kern R. Basin, Calif., re systematics & evolution of western N America *Salmo*; also hybridization)

Trout, lake (*Salvelinus* (*Cristivomer*) *namaycush*) (char; lake char)
J 28(1): 65 (population biology in L. Superior before lamprey invasion)
(3: 448 (subcutaneous fibroma in Que. lake trout)
(4): 465 (intraspecific variations & postglacial distribution)
(6): 815 (mathematical simulation model for growth efficiency)
(9): 1285 (methylmercury in N.B.)
T 176 (bibliography, 1929–1969)
S 1490 (history of Great Lakes fishery re lamprey invasion)
A 200 (mercury contamination, Pinchi L., B.C.)
201 (mercury contamination, Great Lakes)

Trout, rainbow (*Salmo gairdneri*) (when anadromous, *see* Trout, steelhead; *see also* Trout, rainbow (*Salmo irideus*))
J 28(1): 104 (morphology of proteolytic pseudomonad from skin lesions)
(4): 587 (factors influencing scope for activity & active & standard metabolism, for wild vs. hatchery)
(5): 663 (world distribution)
(5): 771 (life history in Batchawana Bay, E L Superior)
(6): 875 (Egtved virus antibody development in)
(7): 947 (blood pathway effects on blood-pressure drop in gills)
(7): 987 (meristic characters re systematics & evolution of western N America *Salmo*)
(7): 1015 (lysosomal triglyceride lipase from lateral line tissue)
(7): 1019 (role of social behaviour in dispersal of introduced)
(8): 1173 (glycoproteins constituents levels in blood sera)
(8): 1181 (growth & fecundity after eyed-embryo exposure to X-rays)
(9): 1253 (antibody production & immunity responses to *columnaris* disease)
(10): 1609 (circulatory & ventilatory responses to gills artificial manipulation)
(11): 1739 (susceptibility to *columnaris* disease)
(11): 1801 (fingerlings temperature selection in vertical & horizontal gradients)
(12): 1899 (stresses caused by formalin disinfection of young)
(12): 1847 (experience effect on predation by)
(12): 1918 (abnormal body curvatures in Norwegian fry)
(12): 1837 (lysolecithin solubilizing effect on tissues extractability)

T 165(F) (farming in central Canada)
245 (mortality, from uncertain cause, Lardeau R., B.C.)
261 (bibliography for Gulf of St. Lawrence)
S 1458 (liver glycosyl transferase re liver glycogen structure)
1484 (molecular structure of halogenated mononitrophenols re their toxicity to fingerlings vs. sea lamprey larvae)
1509 (accelerated denaturation of muscle myosin in frozen solution)
1525 (liver pyrimidine deoxynucleoside phosphorylase & deoxyribosyltransferase)
1554 (respiratory pumps responses to hypoxia)
1561 (sulphydryl content of myosins re protein stability)
1563, 1571 (polypeptides re multiple hemoglobins subunit structures & molecular basis)
A 200 (mercury contamination)

Trout, rainbow (*Salmo irideus*) (*see also* Trout, rainbow (*Salmo gairdneri*))
J 28(12): 1918 (abnormal body curvatures in inbred fry, Norway)

Trout, speckled (*see* Trout, brook)

Trout, steelhead (*Salmo gairdneri*) (steelhead salmon, as anadromous rainbow trout; *see also* Trout, rainbow)
J 28(12): 1915 (egg fertilization with cryo-preserved sperm)
CNG 91 (age & size in Vancouver Is. stream-anglers' catches)
A 204 (catches during INPFC studies, 1965)

Trouts (in general) (*see also* names of species)
J 28(7): 987 (systematics & evolution of western N America *Salmo*)
S 1502 (automatic wet-feed dispenser for fry)

Trust, Trevor John
J 28(8): 1185 (commercial fish diet bacterial counts)

Tsuyuki, Hiroshi
J 28(10): 1621 (taxonomy, distribution & biology of northern rockfish)
(11): 1745 (biochemical & cytological study of suckers)
S 1563 (trout hemoglobins)
1571 (molecular basis for multiplicity of Pac. salmon hemoglobins)

Tube-building
J 28(10): 1433 (re feeding motions of mouth in a terebellid polychaete)

Tube-snout (*Aulorhynchus flavidus*)
J 28(3): 427 (phylogeny, diagnostic features & range)

Tube-snouts
J 28(3): 427 (osteology re phylogenetic relations to sticklebacks; *Aulichthys japonicus* diagnostic characters & range)

Tubeworms (*see* Polychaeta)

Tubifex tubifex (tubificid oligochaete)
J 28(3): 335 (survival of bacteria during ingestion by, in Toronto Harbour, Ont., sediments)

Tubificidae (*see also* Oligochaeta; *Tubifex*)
S 1543 (of Georgian Bay, L. Ontario, & L. Erie; with key)

Tullibee (*see* Cisco, lake)

Tumours (*see also* Disease)
J 28(1): 112 (in cutthroat trout re leukemic condition)
(3): 448 (subcutaneous fibroma in lake trout)
(9): 1241 (incidence and comparisons of, in Pleuronectidae of Bellingham Bay, Wash.)

Tuna, bigeye (*Thunnus obesus*)
A 182 (ICNAF Canadian 1969 research summary)

Tuna, bluefin (*Thunnus thynnus*)
J 28(5): 995 (blood pathway effects on blood-pressure drop in gills)
(7): 1053 (genic polymorphism of blood & tissues tetrazolium oxidase)
T 261 (bibliography for Gulf of St. Lawrence)
272 (halogenated hydrocarbon residues detected in)
A 182 (ICNAF Canadian 1969 research summary)

Tuna, skipjack (*Euthynnus* (*Katsuwonus*) *pelamis*) (skipjack)
J 28(7): 947 (blood pathway effects on blood-pressure drop in gills)
T 272 (halogenated hydrocarbon residues detected in)
A 182 (ICNAF Canadian 1969 research summary)

Tuna, yellowfin (*Thunnus albacares*)
J 28(7): 947 (blood pathway effects on blood-pressure drop in gills)
T 272 (halogenated hydrocarbon residues detected in)
A 182 (ICNAF Canadian 1969 research summary)

Tunicates
T 225 (associated with Bay of Fundy scallop beds)

Turbellaria (flatworms)
J 28(1): 7 (chemical composition & food reserves seasonal changes in freshwater triclad *Dugesia tigrina*)

(6): 849 (sampling from shallow stream bed)
(8): 1198 (supernumerary copulatory organs in *D. tigrina*)
S 1532 (*Polycelis coronata* of a high Colorado mountain creek)

Turbidity of natural waters (*see also* Transparency)
S 1504 (continuous nephelometric measurement of sea water)

Turbot, diamond (*Hypsopsetta guttulata*)
T 246 (bibliography)

Turbot, Greenland (*see* Halibut, Greenland)

Turbot, hornyhead (*Pleuronichthys verticalis*)
T 246 (bibliography)

Turbot, Pacific (*see* Flounder, arrowtooth)

Turbulence (*see* Currents; Tides)

Tursiops truncatus (*see* Porpoise, bottlenose)

Tyler, Albert Vincent
J 28(7): 935 (fish community components)
(11): 1727 (movement of flounder into intertidal zone)

U

Ultrasonics
J 28(8): 1167 (tracking net-avoidance by fish)
(8): 1217 (re distinguishing thawed frozen fish from fresh fish)
A 220 (bio-acoustic program during C.S.S. *Hudson* oceanographic survey circumnavigating N & S America)

Ulvaria subbifurcata (*see* Shanny, radiated)

Union of Soviet Socialistic Republics (USSR)
T 210 (observation of trawling catches off B.C. & Washington coasts, by FRB groundfish surveys)
246 (bibliography of trawl fishery off N America Pac. coast)

United States of America (*see also* certain names of States)
T 246 (bibliography of trawl fishery off N America Pac. coast)

Unloading (of fish)
A 203 (pumping methods for, from boats)

Uranium derivatives
J 28(5): 786 (in dressed Canadian fishes from industrial area lakes)

Urea
J 28(4): 606 (juvenile coho salmon blood urea nitrogen content)

Uria aalgae (*see* Guillemot, common)

Uronema (*see* Ciliata)

Urophycis chesteri (*see* Hake, longfin)
chuss (*see* Hake, red)
regius (*see* Hake, spotted)
tenuis (*see* Hake, white)

Urosalpinx cinerea (*see* Oyster drill, Atlantic)

Uschakov, P. V.
J 28(10): 1403 (amphipacific polychaetes distribution)

USSR (*see* Union of Soviet Socialistic Republics)

Uthe, John Frederick
J 28(5): 786 (heavy metal contamination of freshwater fish)
(8): 1203 (obtaining muscle from live fish)
A 178 (determination of residual mercury in fish tissue)

V

Vaccination
J 28(9): 1253 (of rainbow trout against *columnaris* disease)

Valentine, James William
S 1587 (pleistocene paleoecology and biostratigraphy, Santa Barbara Is., Calif.)

Vallentyne, John Reuben Way
J 28(2): 123 (background of FRB Experimental Lakes, NW Ont.)
A 216 (phosphorus & control of eutrophication)
233 (ecology & our pollution problem)

Vanadium derivatives
S 1529 (distribution in L. Ontario)

Vancouver Island, B.C. (*see also* names of localities and bodies of water; *also* Oceanography, Pacific east coast)
B 178 (oyster raft culture)
CNG 91 (steelhead trout age & size in stream-anglers' catches)
T 232 (razor clam breeding & growth, Long Beach)

van Overbeeke, Abraham Pieter
J 28(4): 477 (gonadal hormones effects on sockeye organs)
(4): 485 (effects of hormones on sockeye)

Vanstone, William Edward
J 28(8): 1173 (Pac. salmon glycoprotein constituents)
(12): 1853 (proteins in salmon eggs)
S 1521 (egg proteins of Pac. salmon)
1584 (soluble fractions of Pac. salmon eggs)

Vegetation (*see* Flora, aquatic; Flora, terrestrial)

Vellela (*see* Hydroids)

Velsen, Frank Peter John
J 28(10): 1545 (salinity & temperature re Pac herring)

Ventilation (*see* Gills; Oxygen, dissolved; Respiration; Stress)

Venus mercenaria (*see* Quahaug, northern)

Vermiliopsis (*see Metavermilia*)

Vertebrae
J 28(4): 465 (counts of N America lake char re postglacial distribution)
(4): 553 (counts of spring vs. autumn spawning SW Nfld. herring)
(7): 987 (counts re systematics & evolution of western N America *Salmo* species & subspecies)
(9): 1235 (count re egg size of medaka)
T 192 (number data for Greenland turbot)
A 192 (number, Atl. & Pac. capelin)
208 (Bay of Fundy herring)

Vessels, research (*see also* Surveys)
T 246 (bibliography of operations re N America Pac. coast trawling)
A 220 (C.S.S. *Hudson* circumnavigation of N & S America)

Vibrio (*see* Vibriosis)

Vibriosis
J 28(4): 517 (first records in Pac. salmon cultured in Canada; morphology & taxonomy of causative bacterium *Vibrio anguillarum*; correction on J 28(8): 1219)
A 203 (*Vibrio parahemolyticus* re fish products toxicity)

Victoria Harbour, B.C.
A 187 (sewage re pollution)

Viruses
J 28(6): 875 (Egtved virus antibody development in artificially infected rainbow trout)
(7): 1064 (infectious pancreatic necrosis, in brook trout feces & organs)
(9): 1350 (infectious pancreatic necrosis, in brook trout in 2 Ont. hatcheries)
(11): 1809 (new records of lymphocystic viral infection in gobiid & diodontid fishes, E Pac. coast)

Viscera (*see also* organs of)
T 198 (lipids, fatty acids, & tocopherol in queen crab)
208 (bioassays of various Nfld. fishes, re elemental phosphorus assimilation & concentration in)
S 1412 (fluoride content, of several Atl. commercial fishes)

Vision (*see also* Darkness; Diel habits; Light, reactions to)
J 28(9): 1352 (moonlight effect on torrent sculpin predation)
(12): 1847 (re experience effect on predation by rainbow trout)

Vitamins
S 1480 (K & tocopherol, of unicellular red alga *Porphyridium cruentum*)

Vitellins; Vitins (*see also* Eggs; Proteins)
J 28(12): 1853 (classification of, in coho salmon eggs)

Vollenweider, Richard Albert
S 1529 (trace elements & chlorophyll in L. Ontario)

Volsella modiolus (*see* Mussel, red)

Vose, John Randal
S 1491 (fission of phenylalanine by marine algae)

Voyer, Richard Alan
J 28(12): 1907 (respiration in flounder)

W

Wadley, Gerald Weldon
J 28(8): 1181 (X-rays effects on trout embryos)

Wahoo (*Acanthocybium solanderi*)
J 28(7): 947 (blood pathways effects on blood-pressure drop in gills)

Waldichuk, Michael
A 187 (coastal sewage pollution)
232 (introduction to report on radioactivity in the marine environment)

Walker, Charles Edward
J 28(5): 647 (pink salmon in Qualicum R.)

Waller, William Thomas
J 28(8): 1107 (computer simulation of pollution minnow deaths)

Walleye (*Stizostedion vitreum vitreum*) (yellow walleye)
J 28(1): 105 (DDT residues in flesh, Saskatchewan R.)

---

(5): 783 (slime as bacterial medium re keeping quality)
(7): 1005 (genetics of skeletal muscle multiple malate dehydrogenase isozymes)
(8): 1133 (migrations of adult & juveniles between L. Huron & L. Erie)
(9): 1303 (effects of oxygen depletion & carbon dioxide accumulation on photic behaviour)
T 261 (bibliography for Gulf of St. Lawrence)
A 200, 201 (mercury contamination, in various Canadian waters)

Walrus (*Odobenus rosmarus*)
MSP 13(F) (actual & potential Canadian Arctic fishery)
A 231 (actual & potential Canadian Arctic fishery)

Warbonnet, Atlantic (*Chirolophis ascanii*) (Yarrel's blenny)
T 261 (bibliography for Gulf of St. Lawrence)

Ware, Daniel Morris
J 28(12): 1847 (learning by rainbow trout)

Warner, Kendall
J 28(4): 537 (jaw tagging Atl. salmon)

Washing (of fish) (*see* Quality of fishery products)

Washington, Lake, Washington, USA
J 28(9): 1331 (zoographic problem re presence of relict *Pontoporeia affinis* amphipod)

Washington State, USA (*see also* Puget Sound; Catches; Groundfish; Trawling; *also* preceding heading and other localities and bodies of water)
J 28(9): 1331 (W distribution of peamouth)
(9): 1335 (age & growth of coastal weathervane scallop)

Waste disposal (*see* Pollution)

Watasenia felis (*Abraliopsis felix*) (*see* Squid)

Waters, natural (*see also* Hardness; Lakes; Limnology; Pollution; Oceanography; Sea water)
J 28(1): 73 (chemistry of 2 thermal springs, Mt. Rainier Natl. Park, USA)
(2): entire issue (of many small lakes in FRB Experimental Lakes Area, NW Ont.)
(5): 759 (rapid ammonium ion determination method)
(7): 1049 (sampler for interstitial water in marine mud)
(7): 1057 (temperature effects of hot discharge water from nuclear power plants)
T 218 (effects of sea water on bacteria survival)
262 (temperature effects from hot water discharge from steam-electric power plants)
S 1485 (importance & general implications of organic matter in aquatic feedc hain, particularly re filter-feeding copepods)

Waterton Lakes National Park, Alta.
J 28(3): 311 (crustacean plankton of a subalpine lake & pond)

Watson, Jeffrey
T 204 (adult male snow crabs tag recaptures & movements)
A 217(F) (biological study of queen crab)

Waugh, Donald Lloyd
J 28(4): 527 (ribbed mussel upper lethal temperatures)

Wavre, Mina
J 28(3): 335 (tubificid oligochaetes & bacteria)

Waxes
S 1514 (wax esters of Amazon R. dolphin jaw fat, re echolocation ability)
1564 (*trans*-6-hexadecenol & corresponding acid in sea anemone)

Weather (*see* Climate)

Weathership Station P (*see* Oceanography, North Pacific Ocean)

Webb, N.A.
T 210 (*G. B. Reed* groundfish cruise 70–2)

Wedemeyer, Gary
J 28(4): 606 (blood chemistry values for juvenile coho salmon)
(12): 1899 (stress of formalin treatment in fish)

Weight (*see also* Growth; Length; Size)
J 28(4): 513 (of Skeena R. sockeye salmon eggs re length & age of parents)
(6): 861 (feeding level effects on young sockeye salmon)
(7): 1061 (reduction on drying white sucker steaks)
(12): 1907 (re factors affecting winter flounder respiration rates)
T 160 (of 4 *Lepidion* morid fish species)
237 (re length of Pac. ocean perch off B.C. in 1969)
250 (computer programming fish data)
260 (at mean length, of Scotian Shelf groundfish species)
S 1575 (of Cetacea & their hearts, re their feeding rates)
A 197, 212 (& size of fish re metabolic energy requirements; reviews)

Weiner, Catherine
S 1519 (protein, amino acids, and ammonia determination in marine sediments)

Weir, J. R.
A 230 (food from a northern environment)

Weisbart, Melvin
S 1576 (hormonal steroids in sturgeon plasma)

Welander, Arthur Donovan
J 28(8): 1181 (X-ray effects on trout embryos)

Wellings, Sefton Robert
J 28(9): 1241 (flounder skin tumors)

Wells, Richard
S 1507 (haddock length conversion factors)
1540 (catch/effort assessment of major cod stocks)
A 191 (American plaice eggs and larvae)

Werner, Arthur Eugene
S 1500 (gases from sediments in polluted coastal waters)

Westrheim, Sigurd Jergen
J 28(10): 1621 (taxonomy, distribution, and biology of northern rockfish)
T 210 (*G. B. Reed* groundfish cruise 70–2)
237 (weight–length relationship for Pac. ocean perch)
251 (length–girth relationship for Pac. ocean perch)
269 (*G. B. Reed* groundfish cruise 71–1)

Whale, bowhead (*Balaena mysticetus*) (Greenland right whale)
J 28(12): 1873 (Canadian recovery after previous exploitation)
A 231 (Canadian Arctic native fishery)

Whale, false killer (*Pseudorca crassidens*)
S 1575 (body & heart weight, re feeding rate)

Whale, fin (*Balaenoptera physalus*)
S 1574 (oral remnants of nasopalatine canals)

Whale, Greenland right (*see* Whale, bowhead)

Whale, killer (*Orcinus orca*)
S 1575 (body & heart weight, re feeding rate)

Whale, minke (*Balaenoptera acutorostrata*)
A 194 (Nfld. fishery)

Whale, Pacific pilot (*Globicephala scammoni*)
S 1575 (body & heart weight, re feeding rate)

Whale, pilot (*Globicephala melaena*) (blackfish; pothead whale)
A 194 (Nfld. fishery)

Whale, southern Atlantic pilot (*Globicephala macrorhyncha*)
S 1575 (body & heart weight, re feeding rate)

Whale, white (*Delphinapterus leucas*) (beluga)
J 28(9): 1309 (growth, reproduction, & behaviour, Cumberland Sound, Baffin Is., N.W.T.)
MSP 13(F) (actual & potential Canadian Arctic fishery)
S 1575 (body & heart weight, re feeding rate)
A 200 (mercury contamination, Hudson Bay)
231 (actual & potential Canadian Arctic fishery)

Whales (*see also* above species)
S 1575 (body lengths, & heart weight re body weight, of various species)
A 194 (Nfld. minor fishery species)
229 (aging by teeth & bone layered structure: book review)

Whelk, rough (*Buccinum undatum*)
B 177 (re paralytic shellfish poisoning, E Canada)

Whelk, Stimpson's (*see* Spindle shell)

Whelk, ten-banded (*Neptunea decemcostata*) (ten-ridged neptune)
B 177 (re paralytic shellfish poisoning, E Canada)

Whelping (*see* Reproduction)

White, Edwin Graeme
J 28(3): 443 (computer analyses of capture–recapture data using Jolly's model)

Whitefish, lake (*Coregonus clupeaformis*)
J 28(5): 643 (killing *Salmonella* bacteria by ^{60}Co irradiation during smoking)
(5): 783 (beneficial effect of washing off slime re keeping quality)
(5): 786 (heavy-metal concentrations in dressed, from Moose L., Man., & L. Ontario)
T 261 (bibliography for Gulf of St. Lawrence)
A 200, 201 (mercury contamination in various Canadian waters)
224 (parasites)

Whitefish, mountain (*Prosopium williamsoni*)
J 28(1): 110 (stomach evacuation rate when fed sockeye salmon alevins)
T 245 : 1 (unknown cause of severe mortality, Kootenay L., B.C.)
A 224 (parasites)

Whiting (Pacific) (*see* Pollock, Pacific)

Whyte, John Nimmo Crosby
S 1530 (polysaccharides of red alga)
1548 (polysaccharides of red seaweed)

Wickett, William Percy
T 230 (Pac. Ocean transport charts, 1969)
238 (N Pac. Ocean transport computations, 1970)
239 (N Pac. Ocean transport computations, 1969)
240 (N Pac. Ocean transport charts, 1970)

Abbreviations: J — *Journal.* B — *Bulletin.* AR — *Annual Report.* R — *Review. Circular Series*: CHN — Halifax; CNG — Nanaimo; CJG — St. John's. T — *Technical Reports.* MSP — *Miscellaneous Special Publications.* S — *Studies.* A — *Interpretive Articles.*

Wilder, Donald George
A 213, 213(F) (artificial rearing of lobsters)

Wildish, David John
J 28(9): 1285 (methylmercury in fish)
S 1558 (lethal effects of PCB in sea water on *Gammarus oceanicus*)
1570 (uptake of polychlorinated biphenyls from sea water by *Gammarus oceanicus*)

Willis, James Newman, III
J 28(11): 1783 (distribution of radioactive zinc in marine ecosystem)

Wilson, Robert McNair
J 28(10): 1681 (whitebait smelt recorded in B.C. waters)

Wind
J 28(2): 163 (effect on thermoclines in several small NW Ont. lakes)

Windowpane (*Scophthalmus aquosus*)
T 225 (associated with Bay of Fundy scallop beds)
261 (bibliography for Gulf of St. Lawrence)

Winnipeg, Lake, Man.
A 200 (mercury contamination of fishes by species & locality)

Winters, George Henry
J 28(7): 1029 (fecundity of capelin)
CJG 18: 20 (herring tagging in SW Nfld. waters)
A 185 (Nfld. capelin)
193 (capelin (*Mallotus villosus*))

Wiseman, Phyllis Maxwell
J 28(10): 1675 (sterols of a brachiopod)
S 1457 (desmosterol content of dulse red algae sterols)
1459 (new marine sterol)
1506 (identification of scallop sterols)
1527 (sterols of Crustacea)

Withler, Frederick Curtis
CNG 91 (Vancouver Is. steelhead trout age & size)

Wold, Finn
J 28(6): 879 (enolase from lobster)

Wolf-eel (Atlantic) (*Lycenchelys paxillus*)
T 261 (bibliography for Gulf of St. Lawrence)

Wolf-eel (Pacific) (*Anarrhichthys ocellatus*)
T 257 (taken in 1970 B.C. trawl fishery)

Wolffish, Atlantic (*Anarhichas lupus*)
J 28(1): 1 (amine production in storedfrozen muscle)
(9): 1285 (methylmercury in, N.S. banks)
T 225 (associated with Bay of Fundy scallop beds)
260 (standing crop, availability, lengths, weights, etc. from Scotian Shelf surveys, 1958–68)
261 (bibliography for Gulf of St. Lawrence)

Wolffish, spotted (*Anarhichas minor*)
T 261 (bibliography for Gulf of St. Lawrence)

Woods, C. S.
T 151 (bibliography of coregonid fishes)

Woods, Robert John
J 28(5): 625 (handling & anesthetization effects on brook trout)
(5): 635 (brook trout variations re surgery)

Worms (*see* Acanthocephala; Annelids; Cestoda; Chaetognatha; Flukes; Leeches; Nematoda; Oligochaeta; Polychaeta; Sandworm; Turbellaria)

Wowchuk, Robert Michael
T 211 (*G. B. Reed* groundfish cruise 70–3)

Wrymouth (*Cryptacanthodes maculatus*)
J 28(7): 935 (occasional component of Passamaquoddy Bay fish communities, N.B.)
T 261 (bibliography for Gulf of St. Lawrence)

Wrymouth, giant (*Delolepis gigantea*)
T 257 (taken during 1970 B.C. trawl fishery)

X

X-rays
J 28(3): 369 (fluorescence X-ray spectrometry of salmonids for elemental composition as indicator of geographical origin)
(8): 1181 (rainbow trout growth & fecundity after eyed-embryo exposure to)
(10): 1583 (radioisotope X-ray fluorescence spectrometry in aquatic biology: review)
T 200 (multiple discrimination analysis of data from J 28(3) reference above)
212 (computer programming of data such as from T 200 reference above)

Xeneretmus triacanthus (*see* Poacher, bluespotted)

Xenon
A 232 (^{133}Xe as radioactive marine pollutant)

Xiphias gladius (*see* Swordfish)

Xystreurys liolepis (*see* Sole, fantail)

Y

Yamamoto, Masanobu
S 1508 (acid deoxyribonuclease from salmon testes)
1525 (fish liver enzymes)
A 226 (nucleoside cyclic phosphate diesterases)
227 (nucleotide phosphomonoesterases)

Yates, Arthur Nelson
A 128(F) (B. C. prawn trap fishing)

Yield (*see also* Angling; Catches; Fisheries; Management)
T 165(F) (in rainbow trout farming, eastern Canada)
260 (maximum sustainable, Scotian Shelf groundfishes)
A 184 (sustained, of Canadian Arctic harp & ringed seals)

Yoho National Park, B.C.
J 28(3): 311 (crustacean plankton of 20 alpine & subalpine lakes and ponds)

Yu, Man-Lim
J 28(1): 47 (erythropoiesis in *Trichogaster trichopterus*)

Yusa, Tatsuo
T 236 (eggs & larvae of *Limanda yokohamae*)

Yvesia (*see* Sponges)

Z

Zalembius rosaceus (*see* Seaperch, pink)

Zaprora silenus (*see* Prowfish)

Zibrowius, Helmut W.
J 28(10): 1373 (revision of *Metavermilia*)

Zinc derivatives
J 28(2): 277 (in sediments of 4 small NW Ont. lakes)
(5): 786 (in dressed Canadian fishes from industrial area lakes)
(6): 843 (biological activity of, as occurring in P.E.I. oysters fed to rats)
(8): 1107 (mathematical model of effects on mortality in fathead minnow populations)
(11): 1783 (distribution of ^{65}Zn vs. Zn in experimental marine ecosystem)
T 202 (diatoms as indicators of, & effects of, in NW Miramichi R. basin, N.B.)
S 1529 (distribution in L. Ontario)
1553 (re mining effluent effects on NW Miramich R. vascular plants)
A 222 (avoidance reaction sensitivity to sub-lethal levels by Atl. salmon & brook trout)
232 (^{65}Zn as radioactive marine pollutant)

Zitko, Vladimir
J 28(9): 1285 (methylmercury in fish)
T 217 (characterization of petroleum oils)
272 (PCB & other industrial halogenated hydrocarbons in the environment)
S 1463 (identification of polychlorinated biphenyls & DDT)
1569 (fuel oil contamination of aquatic animals)
1570 (uptake of polychlorinated biphenyls from sea water by *Gammarus oceanicus*)
1584 (fish kill from coke-oven oil)

Zonation (*see* Distribution)

Zoobenthos (*see* Benthos)

Zoogeography (*see also* Distribution (biological); Glaciation)
J 28(7): 987 (re systematics & evolution of western N America *Salmo*)
(9): 1331 (re glacial relict *Pontoporeia affinis* amphipod in L. Washington, USA)
(10): 1403 (re amphipacific distribution of polychaete species)
S 1532, 1533 (re invertebrates in high mountain North Boulder Creek, Colorado)

Zooplankton (*see also* Feed; Plankton; Production, secondary; *also* classifications of)
J 28(2): 231, 245, 257 (studies in many small NW Ont. lakes)
(4): 559 (seasonal caloric content of freshwater, from 3 small E Ont. lakes)
(9): 1327 (tolerance of copepods to fuel oil & fecal sedimentation of oil from marine oil spills)
(10): 1635 (role in young sockeye salmon diets)
B 176 (synopsis of Canadian Arctic, Pacific, & Atlantic marine; includes an index)
T 248 (herbivores nocturnal vs. continuous grazing re productivity studies)
252 (macrozooplankton ecology & biomass, Scotian Shelf)
266 (data, Frobisher Bay, Baffin Is., N.W.T. 1967–70)
S 1482 (comparison of biomass in eutrophicated Bedford Basin, N.S., with that in St. Margaret's Bay, N.S.)
1485 (role of aquatic organic matter as feed for)
1513 (rations, re marine productivity estimation)
1586 (grazing on phytoplankton, re 25-hour chlorophyll budget study)
A 211 (re feed availability to different trophic levels in marine feed chain)

Zostera marina (*see* Eelgrass)

LIST OF PUBLICATIONS

JOURNAL OF THE FISHERIES RESEARCH BOARD OF CANADA

Abbreviation : J

(A complete list of the contents for the 1971 Volume 28 is included at the back of this issue for binding purposes.)

BULLETINS OF THE FISHERIES RESEARCH BOARD OF CANADA

Abbreviation : B

175. MORSE, N. H. An economic study of the oyster fishery of the Maritime Provinces. viii + 81 p.
176. SHIH, C.-T., A. J. G. FIGUEIRA, AND E. H. GRAINGER. A synopsis of Canadian marine zooplankton. viii + 264 p.
177. PRAKASH, A., J. C. MEDCOF, AND A. D. TENNANT. Paralytic shellfish poisoning in eastern Canada. viii + 88 p.
178. QUAYLE, D. B. Pacific oyster raft culture in British Columbia. vi + 34 p.

CIRCULARS OF THE FISHERIES RESEARCH BOARD OF CANADA

Halifax Laboratory, Halifax, N.S.

Abbreviation : CHN

39. DAMBERGS, N., AND L. W. REGIER. Method for extraction and colorimetric determination of isopropanol in fish protein concentrates. 5 p. [1970]
40. STEWART, J. E., AND J. W. CORNICK. Red crab, *Geryon quinquedens*: 1) recommended live storage temperatures; 2) resistance to gaffkemia, the lobster disease. 2 p. [1970]
41. STEWART, J. E., AND J. W. CORNICK. Disease among stored lobsters (gaffkemia). 5 p. [1970]
42. CORNICK, J. W., AND J. E. STEWART. Disinfection procedures for the control of blood disease (gaffkemia) in lobster storage facilities. 3 p. [1970]

Biological Station, Nanaimo, B.C.

Abbreviation : CNG

90. GODFREY, H. Production of chinook and coho salmon by United States hatcheries. 31 p.
91. NARVER, D. W., AND F. C. WITHLER. Age and size of steelhead trout (*Salmo gairdneri*) in anglers' catches from Vancouver Island, British Columbia, streams. 26 p.

Biological Station, St. John's, Nfld.

Abbreviation : CJG

18. HODDER, V. M. Recent developments in the Newfoundland herring fishery. p. 1–19.
WINTERS, G. H. Preliminary results of herring tagging in southwest Newfoundland coastal waters. p. 20–24.
PARSONS, L. S. Herring investigations in northeast Newfoundland and Labrador. p. 25–28. [1970]

ANNUAL REPORT

Abbreviation : AR

Annual Report Fisheries Research Board of Canada 1970. 52 p. (combined English and French).

REVIEW

Abbreviation : R

Review of the Fisheries Research Board of Canada 1969–1970. 217 p.

MISCELLANEOUS SPECIAL PUBLICATIONS

Abbreviation : MSP

13. KERSWILL, C. J., AND J. G. HUNTER. Etudes dans l'Arctique canadien. 16 p.

TECHNICAL REPORTS OF THE FISHERIES RESEARCH BOARD OF CANADA

Abbreviation : T

151. MARSHALL, K. E., AND C. S. WOODS. A bibliography of the coregonid fishes. 63 p. (Freshwater Institute, Winnipeg)
160. TEMPLEMAN, W. Additional tabular details of distributional, meristic and morphometric data for the paper: A review of the morid fish genus *Lepidion* of the North Atlantic with first records of *Lepidion eques*, from the western North Atlantic (Templeman, 1970). Also, weights, foods and parasites of *Lepidion*. 30 p. (St. John's Biological Station) [1970]
165. JOHNSON, L., G. H. LAWLER, AND L. A. SUNDE. L'élevage de la truite arc-en-ciel dans les prairies du Canada. 15 p. (Freshwater Institute, Winnipeg)
176. MARSHALL, K. E., AND J. J. KELEHER. A bibliography of the lake trout, *Cristovomer namaycush* (Walbaum) 1929–1969. 60 p. (Freshwater Institute, Winnipeg) [1970]
179. LEAR, W. H. Catch statistics, length and age composition of Greenland halibut in the Newfoundland area. 27 p. (St.John's Biological Station) [1970]
192. TEMPLEMAN, W. Additional tabular data related to the paper: Vertebral and other meristic characteristics of Greenland halibut, *Reinhardtius hippoglossoides*, from the northwest Atlantic (Templeman, 1970). 16 p. (St. John's Biological Station) [1970]

199. MERCER, M. C. *A. T. Cameron* cruise 157, otter-trawl survey of the southwestern North Atlantic, February 1969. 66 p. (St. John's Biological Station) [1970]
200. CALAPRICE, J. R. A preliminary report on X-ray spectrometric analysis and discrimination of salmonids from different geographic areas. 35 p. (Nanaimo Biological Station) [1970]
202. BESCH, W. K., M. RICARD, AND R. CANTIN. Utilisation des diatomées benthiques comme indicateurs de pollution minière dans le bassin de la Miramichi N.W. 72 p. (St. Andrews Biological Station) [1970]
204. WATSON, J. Tag recaptures and movements of adult male snow crabs, *Chionoecetes opilio* (O. Fabricius), in the Gaspe region of the Gulf of St. Lawrence. 11 p., 5 fig. (St. Andrews Biological Station) [1970]
209. LEE, P. J., J. A. HANSEN, AND K. E. MARSHALL. Storage and retrieval of indexed and annotated bibliographic references. 43 p. (Freshwater Institute, Winnipeg)
210. WESTRHEIM, S. J., C. W. HAEGELE, U. B. G. KRISTIANSEN, AND N. A. WEBB. *G. B. Reed* groundfish cruise No. 70-2, August 7–20, 1970. 15 p. (Nanaimo Biological Station) [1970]
211. MINKLEY, B. G., K. A. GANTZER, AND D. A. HEALEY. Oceanographic observations at Ocean Station P (50°N, 145°W), September 19 to November 6, 1969 and December 5, 1969 to January 15, 1970. 97 p. (Nanaimo Biological Station) [1970]
212. THOMSUN, J. A., AND J. R. CALAPRICE. IBM 1130 programs for multiple discrimination analysis of X-ray spectroscopy data (Fortran). 41 p. (Nanaimo Biological Station) [1970]
213. TAYLOR, F. H. C., L. W. BARNER, AND D. C. MILLER. The British Columbia offshore herring survey, 1969–70. Report on cruises SK 70-4, -5, -6, and -7. 75 p. (Nanaimo Biological Station) [1970]
215. BELL, W. H., AND M. C. ARMSTRONG. A photoelectric fish counter. 23 p. (Nanaimo Biological Station) [1970]
216. FORRESTER, C. R., AND J. E. SMITH. A summary report of the British Columbia trawl fishery in 1969 and some aspects of its investigation. 37 p. (Nanaimo Biological Station) [1970]
217. ZITKO, V., AND W. V. CARSON. The characterization of petroleum oils and their determination in the aquatic environment. 29 p. (St. Andrews Biological Station) [1970]
218. BERNARD, F. R. Factors influencing the viability and behaviour of the enteric bacterium *Escherichia coli* in estuarine waters. 30 p. (Nanaimo Biological Station) [1970]
219. SHARAF EL DIN, S. H., E. M. HASSAN, AND R. W. TRITES. The physical oceanography of St. Margaret's Bay. 242 p. (Marine Ecology Laboratory, Dartmouth) [1970]
220. TOMLINSON, N., D. E. KRAMER, S. E. GEIGER, S. W. ROACH, AND J. H. MANN. Storage of Pacific salmon at sea. 3. The quality of sockeye salmon (*Oncorhynchus nerka*) canned after storage in ice and in refrigerated sea water. 9 p. (Vancouver Laboratory) [1970]
221. HARLING, W. R., D. DAVENPORT, M. S. SMITH, AND R. M. WOWCHUK. *G. B. Reed* groundfish cruise No. 70-3, September 9 to 25, 1970. 35 p. (Nanaimo Biological Station) [1970]
222. CALAPRICE, J. R. Genetics and mariculture. 10 p. (Nanaimo Biological Station) [1970]
223. BILTON, H. T. Data and computations used in racial analyses of age -1.2 and -1.3 North American sockeye on the basis of their scale characters. 57 p. (Nanaimo Biological Station) [1970]
224. SMITH, T. G. Computer programs for analysis of ringed seal population data. 45 p. (Arctic Biological Station, Ste. Anne de Bellevue)
225. CADDY, J. F. Records of associated fauna in scallop dredge hauls from the Bay of Fundy. 11 p., 3 tables, 10 fig. (St. Andrews Biological Station) [1970]
226. PIPPY, J. H. C. Fish mortalities in the Northwest Miramichi River in 1969. 7 p. (St. John's Biological Station) [1970]
229. BROCKERHOFF, H., AND P. H. ODENSE. Effects of adaptive and nonadaptive feeding of hydrogenated and raw herring oil on hearts and livers of rats. 11 p. (Halifax Laboratory) [1970]
230. WICKETT, W. P., AND J. A. C. THOMSON. Ekman transport charts for the North Pacific Ocean, 1969. 27 p. (Nanaimo Biological Station) [1970]
231. HUNTER, J. G. Production of Arctic char (*Salvelinus alpinus* Linnaeus) in a small arctic lake. 190 p. (Arctic Biological Station, Ste. Anne de Bellevue) [1970]
232. BOURNE, N., AND D. B. QUAYLE. Breeding and growth of razor clams in British Columbia. 42 p. (Nanaimo Biological Station) [1970]
233. ACKMAN, R. G., R. F. ADDISON, P. J. KE, AND J. C. SIPOS. Examination of bottom deposits, Long Harbour, Newfoundland, for elemental phosphorus and for fluorides. 6 p., 13 fig. (Halifax Laboratory)
234. BILTON, H. T. Data and computations used in racial analyses of even- and odd-year North American pink salmon on the basis of their scale characters. 10 p. (Nanaimo Biological Station)
235. SCRIVENER, J. C. E. Agonistic behaviour of the American lobster *Homarus americanus* (Milne-Edwards). 128 p. (Nanaimo Biological Station)
236. YUSA, T., C. R. FORRESTER, AND C. IIOKA. Eggs and larvae of *Limanda yokohamae* (Günther). 21 p. (Nanaimo Biological Station)
237. WESTRHEIM, S. J., AND J. A. THOMSON. Weight–length relationship for Pacific ocean perch (*Sebastes alutus*) collected off British Columbia in 1969. 12 p. (Nanaimo Biological Station)

238. WICKETT, W. P., AND J. A. THOMSON. Transport computations for the North Pacific Ocean, 1970. 104 p. (Nanaimo Biological Station)
239. WICKETT, W. P., AND J. A. THOMSON. Transport computations for the North Pacific Ocean, 1969. 104 p. (Nanaimo Biological Station)
240. WICKETT, W. P., AND J. A. C. THOMSON. Ekman transport charts for the North Pacific Ocean, 1970. 27 p. (Nanaimo Biological Station)
241. SCRIVENER, J. C., AND T. H. BUTLER. A bibliography of shrimps of the family Pandalidae, emphasizing economically important species of the genus *Pandalus*. 42 p. (Nanaimo Biological Station)
242. TOMLINSON, N., S. E. GEIGER, S. W. ROACH, AND J. H. MANN. Storage of Pacific salmon at sea. 4. Partial freezing. The harmful effect of slow cooling and of physical maltreatment of the fish. 10 p. (Vancouver Laboratory)
243. KENNEDY, W. A., AND M. S. SMITH. Sablefish culture — progress in 1970. 18 p. (Nanaimo Biological Station)
244. LEE, P. J. Multivariate analysis for the fisheries biology. 182 p. (Freshwater Institute, Winnipeg)
245. BELL, G. R., AND G. E. HOSKINS. Investigations of wild fish mortalities in B.C., 1969–1970. 17 p., Appendix. (Nanaimo Biological Station)
246. DAY, D., AND C. R. FORRESTER. A preliminary bibliography on the trawl fishery and groundfish of the Pacific coast of North America. 91 p. (Nanaimo Biological Station)
247. PLATT, T., AND B. IRWIN. Phytoplankton production and nutrients in Bedford Basin, 1969–70. 172 p. (Marine Ecology Laboratory, Dartmouth)
248. MCALLISTER, C. D. Some aspects of nocturnal and continuous grazing by planktonic herbivores in relation to production studies. 281 p. (Nanaimo Biological Station)
249. ACKMAN, R. G., S. N. HOOPER, AND G. DUBÉ. Development of methodology for the identification of marine oils in hydrogenated edible oil products. 31 p. (Halifax Laboratory)
250. LEE, P. J. The principle and operation of fish catch and pollution. (Freshwater Institute, Winnipeg)
251. WESTRHEIM, S. J., AND F. W. NASH. Length–girth relationship for Pacific ocean perch (*Sebastes alutus*) collected off British Columbia in 1969. 6 p. (Nanaimo Biological Station)
252. SAMEOTO, D. D. The distribution of herring (*Clupea harengus L.*) larvae along the southern coast of Nova Scotia with some observations on the ecology of herring larvae and the biomass of macrozooplankton on the Scotian Shelf. 72 p. (Marine Ecology Laboratory, Dartmouth)
253. TABATA, S., J. A. STICKLAND, AND B. R. DE LANGE BOOM. The program of current velocity and water temperature observations from moored instruments in the Strait of Georgia — 1968–1970 and examples of records obtained. 222 p. (Nanaimo Biological Station)
254. ADDISON, R. F., R. G. ACKMAN, L. J. COWLEY, D. MASCALUK, AND S. POND. Elemental phosphorus levels in water samples from Long Harbour, Nfld. (July, 1969–June, 1970). 29 p. (Halifax Laboratory)
255. FLETCHER, G. L., R. J. HOYLE, AND D. A. HORNE. The relative toxicities of yellow phosphorus production wastes to seawater-maintained fish. 14 p., 4 fig. (Halifax Laboratory)
256. CADDY, J. E., AND A. SREEDHARAN. The effect of recent recruitment to the Georges Bank scallop fishery on meat sizes landed by the offshore fleet in the summer of 1970. 11 p., 3 tables 3 app., 9 fig. (St. Andrews Biological Station)
257. SMITH, J. E. Catch and effort statistics of the British Columbia trawl fishery in 1970. 97 p. (Nanaimo Biological Station)
258. FLANNAGAN, J. F. Toxicity evaluation of trisodium nitrilotriacetate to selected aquatic invertebrates and amphibians. 15 p., 6 fig. (Freshwater Institute, Winnipeg)
259. CHILTON, D. E., AND J. E. SMITH. Length anp age composition of rock sole, *Lepidopsetta bilineata*, in western Canadian waters. 2. Commercial landings from the Cape Scott Bank, Queen Charlotte Sound, 1959–69. 25 p. (Nanaimo Biological Station)
260. SCOTT, J. S. Abundance of groundfishes on the Scotian Shelf. 8 p., 2 fig., 8 tables. (St. Andrews Biological Station)
261. SRIVASTAVA, V. M. Fish of the Gulf of St. Lawrence an unabridged bibliography. 141 p. (Marine Ecology Laboratory, Dartmouth)
264. CARROTHERS, P. J. G. Fluid mechanics of netting and low solidity screens. 1. Apparatus, experimental method, and basic data. 41 p., 45 fig., 11 tables. (St. Andrews Biological Station)
265. GRAINGER, E. H. Biological oceanographic observations in Frobisher Bay. I. Physical, nutrient and primary production data, 1967–1971. 75 p. (Arctic Biological Station, Ste. Anne de Bellevue)
266. GRAINGER, E. H. Biological oceanographic observations in Frobisher Bay. II. Zooplankton data, 1967–1970. 61 p. (Arctic Biological Station, Ste. Anne de Bellevue)
267. BURSA, A. S. Biological oceanographic observations in Frobisher Bay. III. Phytoplankton tables, 1967. 21 p. (Arctic Biological Station, Ste. Anne de Bellevue)
268. BERNARD, F. R. British Columbia marine faunistic survey report on the Brachiopoda. 10 p. (Nanaimo Biological Station)
269. DAVENPORT, D., M. S. SMITH, U. B. G. KRISTIANSEN, J. E. PETERS, AND S. J. WESTRHEIM. *G. B. Reed* groundfish cruise No. 71-1 June 9 to 29, 1971. 27 p. (Nanaimo Biological Station)

270. MAY, A. W., AND W. H. LEAR. Digest of Canadian Atlantic salmon catch statistics. 106 p. (St. John's Biological Station)
271. KEYTE, F. K., AND R. W. TRITES. Circulation patterns in the Gulf of St. Lawrence: June 1968 and September 1969. 108 p. (Marine Ecology Laboratory, Dartmouth)
272. ZITKO, V., AND P. M. K. CHOI. PCB and other industrial halogenated hydrocarbons in the environment. 55 p., 9 fig. (St. Andrews Biological Station)

STUDIES OF THE FISHERIES RESEARCH BOARD OF CANADA

Abbreviation : S

1457. IDLER, D. R., AND P. WISEMAN. 1970. Sterols in red algae (Rhodophyceae): variation in the desmosterol content of dulse (*Rhodymenia palmata*). Comp. Biochem. Physiol. 35: 679–687.
1458. INGRAM, P. 1970. α-I, 4-Glucan: α-I, 4-glucan 6-glycosyl transferase from trout liver. Int. J. Biochem. 1: 451–456.
1459. IDLER, D. R., P. M. WISEMAN, AND L. M. SAFE. 1970. A new marine sterol, 22-*trans*-24-norcholesta-5,22-dien-3β-ol. Steroids 16: 451–461.
1460. LAYCOCK, R. A., AND L. W. REGIER. 1970. Pseudomonads and achromobacters in the spoilage of irradiated haddock of different preirradiation quality. Appl. Microbiol. 20: 333–341.
1461. SCOTT, K. R. 1970. Thermistor readout monitors cold storage. Can. Contr. Instrum. 9: 36–38.
1462. BROCKERHOFF, H. 1970. Substrate specificity of pancreatic lipase. Influence of the structure of fatty acids on the reactivity of esters. Biochim. Biophys. Acta 212: 92–101.
1463. HUTZINGER, O., W. D. JAMIESON, AND V. ZITKO. 1970. Identification of polychlorinated biphenyls and DDT in mixtures by mass spectrometry. Nature 226: 664.
1464. MESSIEH, S. N., AND S. N. TIBBO. 1970. A critique on the use of otoliths for ageing Gulf of St. Lawrence herring (*Clupea harengus* L.). J. Cons. Cons. Int. Perm. Explor. Mer 33: 181–191.
1465. MASON, J. C. 1970. Copulatory behavior of the crayfish, *Pacifastacus trowbridgii* (Stimpson). Can. J. Zool. 48: 969–976.
1466. PARSONS, T. R., AND G. C. ANDERSON. 1970. Large scale studies of primary production in the North Pacific Ocean. Deep-Sea Res. 17: 765–776.
1467. STEPHENS, K. 1970. Automated measurement of dissolved nutrients. Deep-Sea Res. 17: 393–396.
1468. MASON, J. C. 1970. Egg-laying in the western North American crayfish, *Pacifastacus trowbridgii* (Stimpson) (Decapoda, Astacidae). Crustaceana 19(44): 37–42.
1469. BERNARD, F. R. 1970. Occurrence of the spirochaete genus *Cristispira* in western Canadian marine bivalves. Veliger 13: 33–36.
1470. BERNARD, F. R. 1970. A distributional checklist of the marine molluscs of British Columbia: based on faunistic surveys since 1950. Syesis 3: 75–94.
1471. BROCKERHOFF, H., R. J. HOYLE, AND P. C. HWANG. 1970. An assay of lipase based on the liberation of acetaldehyde from vinyl oleate. Anal. Biochem. 37: 26–31.
1472. CUNNINGHAM, C. C., AND I. W. DUEDALL. 1970. Phenosafranin indicator for chlorinity titrations. J. Cons. Cons. Perm. Int. Explor. Mer 33: 292–293.
1473. SCOTT, K. R. 1970. Portable refrigerated fish holding unit for remote freshwater fisheries. Can. Inst. Food Technol. J. 3: 139–142.
1474. ADDISON, R. F., AND R. G. ACKMAN. 1970. Exceptional occurrence of odd-chain fatty acids in smelt (*Osmerus mordax*) from Jeddore Harbour, Nova Scotia. Lipids 5: 554–557.
1475. ACKMAN, R. G. 1970. Confusion between C_{18} and C_{20} fatty acids in a gas chromatographic analysis of seed lipids of water plants. Lipids 5: 950–951.
1476. DICKIE, L. M. 1970. Marine science and technology. Chem. Can. 22(November): 25–27.
1477. O'HALLORAN, M. J., AND D. R. IDLER. 1970. Identification and distribution of the Leydig cell homolog in the testis of sexually mature Atlantic salmon (*Salmo salar*). Gen. Comp. Endocrinol. 15: 361–364.
1478. IDLER, D. R., AND M. J. O'HALLORAN. 1970. Steroids of a chondrostean: identification of interrenal tissue in the American Atlantic sturgeon, *Acipenser oxyrhynchus* Mitchill, by histological and histochemical methods. J. Endocrinol. 48: 621–626.
1479. IDLER, D. R., AND G. B. SANGALANG. 1970. Steroids of a chondrostean: in-vitro steroidogenesis in yellow bodies isolated from kidneys and along the posterior cardinal veins of the American Atlantic sturgeon, *Acipenser oxyrhynchus* Mitchill. J. Endocrinol. 48: 627–637.
1480. ANTIA, N. J., I. D. DESAI, AND M. J. ROMILLY. 1970. The tocopherol, vitamin K, and related isoprenoid quinone composition of a unicellular red alga (*Porphyridium cruentum*). J. Phycol. 6: 305–312.
1481. ACKMAN, R. G., AND S. N. HOOPER. 1970. Hydrogenolysis products of the minor fatty acids from *Euphoria longana* seed oil. J. Amer. Oil Chemists' Soc. 47: 525–529.
1482. PLATT, T., R. J. CONOVER, R. LOUCKS, K. H. MANN, D. L. PEER, A. PRAKASH, AND D. D. SAMEOTO. 1970. Study of a eutrophicated

marine basin. FAO technical conference on marine pollution and its effects on living resources and fishing. December 9–18, 1970, Rome, Italy.

1483. SCOTT, J. S. 1969. Morphology and morphometric variation in *Lecithophyllum botryophorum* (Trematoda: Hemiuridae) in *Argentina silus*. Can. J. Zool. 47: 213–216.

1484. APPLEGATE, V. C., B. G. H. JOHNSON, AND M. A. SMITH. 1966. The relation between molecular structure and biological activity among mononitrophenols containing halogens. Great Lakes Fish. Comm. Tech. Rep. 11: 1–19.

1485. PARSONS, T. R., AND H. SEKI. 1970. Importance and general implications of organic matter in aquatic environments. *In* D. W. Hood [ed.] Symposium on organic matter in natural waters. Inst. Mar. Sci. Occas. Publ. 1(June): 1–27.

1486. MASON. J. C. 1970. Maternal-offspring behavior of the crayfish, *Pacifastacus trowbridgi* (Stimpson). Amer. Midland Natur. 84: 463–473.

1487. MARGOLIS, L. 1970. Nematode diseases of marine fishes, p. 190–209. *In* S. F. Snieszko [ed.] A symposium on diseases of fishes and shellfishes. Amer. Fish. Soc. Spec. Publ. 5.

1488. BURSA, A. S. 1969. *Actiniscus canadensis* n.sp., *A. pentasterias* Ehrenberg v. *arcticus* n.var., *Pseudoactiniscus apentasterias* n.gen., n.sp., marine relicts in Canadian Arctic lakes. J. Protozool. 16: 411–418.

1489. FREEMAN, H. C., AND D. R. IDLER. 1971. Binding affinities of blood proteins for sex hormones and corticosteroids in fish. Steroids 17: 233–250.

1490. LAWRIE, A. H. 1970. The sea lamprey in the Great Lakes. Trans. Amer. Fish. Soc. 99: 766–775.

1491. VOSE, J. R., J. Y. CHENG, N. J. ANTIA, AND G. H. N. TOWERS. 1971. The catabolic fission of the aromatic ring of phenylalanine by marine planktonic algae. Can. J. Bot. 49: 259–261.

1492. HALLIDAY, R. G., AND F. D. MCCRACKEN. 1970. Movements of haddock tagged off Digby, Nova Scotia. ICNAF Res. Bull. 7: 8–14.

1493. PINHORN, A. T. 1970. Assessments of the effects of increases in the mesh sizes of trawls on the cod fisheries in the southern Grand Bank area (ICNAF Divisions 3N and 3O). ICNAF Res. Bull. 7: 32–45.

1494. KNIGHT, W. 1970. Some remarks on the behaviour of growth and mortality estimates based on age–length keys. ICNAF Res. Bull. 7: 52–55.

1495. MESSIEH, S. N. 1970. Immature herring populations in the Bay of Fundy. ICNAF Res Bull. 7: 59–66.

1496. KABATA, Z. 1967. *Proclavellodes pillaii* gen. et sp.n. (Copepoda:Lernaeopodidae) from South India. J. Parasitol. 53: 1298–1301.

1497. EVELYN, T. P. T. 1967. The metabolism of putrescine (1,4-diaminobutane) by mycobacteria isolated from fish. I. Preliminary studies with intact cells. Can. J. Microbiol. 13: 511–519.

1498. EVELYN, T. P. T. 1967. The metabolism of putrescine (1,4-diaminobutane) by mycobacteria isolated from fish. II. Studies with arsenite-inhibited cells and cell-free extracts. Can. J. Microbiol. 13: 521–531.

1499. PARKER, R. R., AND L. MARGOLIS. 1967. A redescription of the syntypes of *Caligus rapax* H. Milne Edwards, 1840 (Copepoda, Caligidae) and the misuse of this name since 1850. Crustaceana 12: 87–101.

1500. WERNER, A. E. 1968. Gases from sediments in polluted coastal waters. Pulp Paper Mag. Can. 69: 127–136.

1501. KABATA, Z. 1967. The genus *Haemobaphes* (Copepoda:Lernaeoceridae) in the waters of British Columbia. Can. J. Zool. 45: 853–875.

1502. POZAR, D. F. 1968. An automatic wet-food dispenser. Progr. Fish-Cult. 30: 113–115. (1)

1503. SHELDON, R. W., T. P. T. EVELYN, AND T. R. PARSONS. 1967. On the occurrence and formation of small particles in seawater. Limnol. Oceanogr. 12: 367–375.

1504. STEPHENS, K. 1967. Continuous measurement of turbidity. Deep-Sea Res. 14: 465–467. (1)

1505. KE, P. J., AND L. W. REGIER. 1971. Direct potentiometric determination of fluoride in water after 8-hydroxyquinoline extraction. Anal. Chim. Acta 53: 23–29.

1506. IDLER, D. R., AND P. WISEMAN. 1971. Identification of 22-*cis*-cholesta-5,22-dien-3β-ol and other scallop sterols by gas–liquid chromatography and mass spectrometry. Comp. Biochem. Physiol. 38A: 581–590.

1507. WELLS, R. 1968. Haddock length conversion factors for St. Pierre Bank. Int. Comm. Nothwest Atl. Fish. Res. Bull. 5: 137–140. (9)

1508. YAMAMOTO, M. 1971. Purification and some properties of an acid deoxyribonuclease from testes of chinook salmon *Oncorhychus tshawytscha*. Biochim. Biophys. Acta 228: 95–104.

1509. BUTTKUS, H. 1970. Accelerated denaturation of myosin in frozen solution. J. Food Sci. 35: 558–562.

1510. SPRAGUE, J. B. 1970. Measurement of pollutant toxicity to fish. II. Utilizing and applying bioassay results. Water Res. 4: 3–32.

1511. EMERY, K. O., C. A. KAYE, D. H. LORING, AND D. J. G. NOTA. 1968. European cretaceous flints on the coast of North America. Science 160: 1225–1228.

1512. PLATFORD, R. F. 1968. Isopiestic measurements on the system water–sodium chloride–

magnesium chioride at 25°. J. Phys. Chem. 72: 4053–4057.

1513. McALLISTER, C. D. 1970. Zooplankton rations, phytoplankton mortality and the estimation of marine production, p. 419–457. *In* J. H. Steele [ed.] Marine food chains. Oliver & Boyd, Edinburgh.

1514. ACKMAN, R. G., C. A. EATON, AND C. LITCHFIELD. 1971. Composition of wax esters, triglycerides and diacyl glyceryl ethers in the jaw and blubber fats of the Amazon River dolphin (*Inia geoffrensis*). Lipids 6: 69–77.

1515. PLATFORD, R. F. 1968. Isopiestic measurements on the system H_2O–NaCl–Na_2SO_4 at 25° C. J. Chem. Eng. Data 13: 46–48.

1516. BUDLONG, J. P. 1968. Bridge and amplifier monitor d-c level. Electronics Sept. 2: 71–72.

1517. BUDLONG, J. P. 1969. UJT gives frequency divider an immunity to input jitter. Electronics July 7: 105.

1518. BUTLER, T. H. 1970. Synopsis of biological data on the prawn *Pandalus platyceros* Brandt, 1851. FAO Fish. Rep. 4: 1288–1315.

1519. GREENFIELD, L. J., R. D. HAMILTON, AND C. WEINER. 1970. Nondestructive determination of protein, total amino acids, and ammonia in marine sediments. Bull. Mar. Sci. 20: 289–304.

1520. PIPPY, J. H. C., AND F. A. ALDRICH. 1969. *Hepatoxylon trichiuri* (Holden 1802) (Cestoda–Trypanorhyncha) from the giant squid *Architeuthis dux* Steenstrup 1857 in Newfoundland. Can. J. Zool. 47: 263–264.

1521. MARKERT, J. R., AND W. E. VANSTONE. 1968. Egg proteins of Pacific salmon, genus *Oncorhynchus*: proteins in the soluble fraction. Can. J. Biochem. 46: 1334–1337.

1522. GOLDSACK, D. E., R. E. HURST, AND J. LOVE. 1969. A pressure jump apparatus with optical detection. Anal. Biochem. 28: 273–281.

1523. TARR, H. L. A., AND J. E. ROY. 1967. Fish-muscle purine and pyrimidine nucleoside phosphorylases. Can. J. Biochem. 45: 409–419.

1524. ROY, J. E., AND K. L. ROY. 1967. The mechanism and specificity of guanine deaminase. Can. J. Biochem. 45: 1263–1269.

1525. TARR, H. L. A., J. E. ROY, AND M. YAMAMOTO. 1968. Fish liver pyrimidine deoxynucleoside phosphorylase and deoxyribosyltransferase. Can. J. Biochem. 46: 407–415.

1526. BUTLER, D. G., E. M. DONALDSON, and W. C. CLARKE. 1969. Physiological evidence for a pituitary–adrenocortical feedback mechanism in the eel (*Anguilla rostrata*). Gen. Comp. Endocrinol. 12: 173–176.

1527. IDLER, D. R., AND P. WISEMAN. 1971. Sterols of Crustacea. Int. J. Biochem. 2: 91–98. (8)

1528. COX, R. E., J. R. MAXWELL, G. EGLINTON, C. T. PILLINGER, R. G. ACHMAN, and S. N. HOOPER. 1970. The geological fate of chlorophyll: the absolute stereochemistries of a series of acyclic isoprenoid acids in a 50 million year old lacustrine sediment. Chem. Commun. 1970: 1639–1641.

1529. CHAU, Y. K., V. K. CHAWLA, H. F. NICHOLSON, AND R. A. VOLLENWEIDER. 1970. Distribution of trace elements and chlorophyll *a* in Lake Ontario. Proc. Conf. Great Lakes Res. 13: 659–672.

1530. WHYTE, J. N. C., AND J. R. ENGLAR. 1971. Polysaccharides of the red alga *Rhodymenia pertusa* Part II. Cell-wall glucan; proton magnetic resonance studies on permethylated polysaccharides. Can. J. Chem. 49: 1302–1305.

1531. KASON, W. R., S. NAKAI, AND R. J. BOSE. 1971. Interaction of α_{s1}-casein with polyethylenimine. J. Dairy Sci. 54: 461–466.

1532. ELGMORK, K., AND O. A. SAETHER. 1970. Distribution of invertebrates in a high mountain brook in the Colorado Rocky Mountains. Univ. Colo. Stud. Ser. Biol. 31: 1–55 p.

1533. SAETHER, O. A. 1970. Chironomids and other invertebrates from North Boulder Creek, Colorado. Univ. Colo. Stud. Ser. Biol. 31: 56–114.

1534. STAINTON, M. P. 1971. Syringe procedure for transfer of nanogram quantities of mercury vapor for flameless atomic absorption spectrophotometry. Anal. Chem. 43: 625–627.

1535. LILEY, N. R., AND E. M. DONALDSON. 1969. The effects of salmon pituitary gonadotropin on the ovary and the sexual behavior of the female guppy, *Poecilia reticulata*.

1536. HAMILTON, A. L., AND O. A. SAETHER. 1971. The occurrence of characteristic deformities in the chironomid larvae of several Canadian lakes. Can. Entomol. 103: 363–368.

1537. SHELDON, R. W. 1969. A universal grade scale for particulate materials. Proc. Geol. Soc. London 1659: 293–295.

1538. PLATT, T., AND D. V. SUBBARAO. 1970. Energy flow and species diversity in a marine phytoplankton bloom. Nature 227(5262): 1059–1060.

1539. TRITES, R. W. 1969. Capacity of an estuary to accept pollutants, p. 148–160. *In* Proceedings of the conference on pollution, St. Mary's University, Halifax, N.S., Aug. 24–26, 1969. Chemical Institute of Canada, Ottawa, Ont.

1540. PINHORN, A. T., AND R. WELLS. 1970. Catch/effort assessments for the major cod stocks in ICNAF Subareas 2 and 3. Int. Comm. Northwest Atl. Fish. Redbook 1970(3): 65–74.

1541. PITT, T. K. 1970. Trends in the American plaice fishery in ICNAF Subarea 3. Int. Comm. Northwest Atl. Fish. Redbook 1970(3): 103–110.

1542. TEMPLEMAN, W. 1970. Temperatures and salinities in the eastern Newfoundland area in 1969. Int. Comm. Northwest Atl. Fish. Redbook 1970(3): 11–21.

1543. BRINKHURST, R. O., A. L. HAMILTON, AND H. B. HERRINGTON. 1968. Components of the bottom fauna of the St. Lawrence, Great Lakes. Great Lakes Inst. Univ. Toronto PR 33: 50 p.

1544. MERCER, M. C. 1970. Sur la limite septentrionale du calmar. Natur. Can. 97: 823–824.

1545. NYMAN, O. L. 1970. Electrophoretic analysis of hybrids between salmon (*Salmo salar* L.) and trout (*Salmo trutta* L.) Trans. Amer. Fish. Soc. 99: 229–236.

1546. MERCER, M. C. 1970. Cephalopod resources and fisheries in the Northwest Atlantic. Amer. Malacol. Union Annu. Rep. Bull. 1970: 30–33.

1547. NYMAN, O. L. 1970. Ecological interaction of brown trout, *Salmo trutta* L., and brook trout, *Salvelinus fontinalis* (Mitchill), in a stream. Can. Field-Natur. 84: 343–350.

1548. WHYTE, J. N. C. 1971. Polysaccharides of the red seaweed *Rhodymenia pertusa* Part I. Water-soluble glucan. Carbohydrate Res. 16: 220–224.

1549. BOSE, R. J., AND M. D. PETERS. 1971. Occurrence and origin of the tropylium ion in the mass spectra of arylboronic acid esters. Can. J. Chem. 49: 1766–1770.

1550. SUTTERLIN, A. M., AND R. L. SAUNDERS. 1969. Proprioceptors in the gills of teleosts. Can. J. Zool. 47: 1209–1212.

1551. CADDY, J. F. 1969. Development of mantle organs, feeding, and locomotion in postlarval *Macoma balthica* (L.) (Lamellibranchiata). Can. J. Zool. 47: 609–617.

1552. SPRAGUE, J. B., P. F. ELSON, AND J. R. DUFFY. 1971. Decrease in DDT residues in young salmon after forest spraying in New Brunswick. Environ. Pollut. 1: 191–203.

1553. BESCH, K. W., AND P. ROBERTS-PICHETTE. 1970. Effects of mining pollution on vascular plants in the Northwest Miramichi River system. Can. J. Bot. 48: 1647–1656.

1554. HUGHES, G. M., AND R. L. SAUNDERS. 1970. Responses of the respiratory pumps to hypoxia in the rainbow trout (*Salmo gairdneri*). J. Exp. Biol. 53: 529–545.

1555. SYMONS, P. E. K. 1970. Claw-shuddering behavior of the shore crab *Hemigrapsus oregonensis*. Can. Field Natur. 84(1): 2 p. (6)

1556. PETERSON, R. H., AND J. M. ANDERSON. 1969. Effects of temperature on brain tissue oxygen consumption in salmonid fishes. Can. J. Zool. 47: 1345–1353.

1557. AIKEN, D. E. 1969. Ovarian maturation and egg laying in the crayfish *Orconectes virilis*: influence of temperature and photoperiod. Can. J. Zool. 47: 931–935.

1558. WILDISH, D. J. 1970. The toxicity of polychlorinated biphenyls (PCB) in sea water to *Gammarus oceanicus*. Bull. Environ. Contam. Toxicol. 5: 202–204.

1559. HAMILTON, R. D., AND J. E. PRESLAN. 1969. Cultural characteristics of a pelagic marine hymenostome ciliate, *Uronema* sp. J. Exp. Mar. Biol. Ecol. 4: 90–99.

1560. TARR, H. L. A., AND L. GARDNER. 1971. Deoxyribonucleic acid polymerase from immature testes of salmon. Can. J. Biochem. 49: 19–27.

1561. BUTTKUS, H. 1971. The sulfhydryl content of rabbit and trout myosins in relation to protein stability. Can. J. Biochem. 49: 97–107. (2)

1562. IDLER, D. R., D. A. HORNE, AND G. B. SANGALANG. 1971. Identification and quantification of the major androgens in testicular and peripheral plasma of Atlantic salmon (*Salmo salar*) during sexual maturation. Gen. Comp. Endocrinol. 16: 257–267.

1563. RONALD, A. P., AND H. TSUYUKI. 1971. The subunit structures and the molecular basis of the multiple hemoglobins of two species of trout. *Salmo gairdneri* and *S. clarki clarki*. Comp. Biochem. Physiol. 39B: 195–202.

1564. HOOPER, S. N., AND R. G. ACKMAN. 1971. Trans-6-hexadecenoic acid and the corresponding alcohol in lipids of the sea anemone *Metridium dianthus*. Lipids 6: 341–346.

1565. BOYCE, N. P. J. 1971. An instrument for removing cephalic sections of nematodes. Trans. Amer. Microsc. Soc. 90: 89–92.

1566. KABATA, Z. 1971. *Lernanthropus togatus* sp. n. (Copepoda: Dichelesthiidae), a parasite of *Gaterin* sp. (Pisces: Teleostei) in the Indian Ocean. J. Parasitol. 57: 157–160.

1567. KABATA, Z. 1970. Crustacea as enemies of fishes. *In* S. F. Snieszko and H. R. Axelrod [ed.] Diseases of fishes. Book 1. T. F. H. Publications, Inc., Jersey City, New Jersey. 197 p. + 105 fig.

1568. KABATA, Z. 1970. Copepoda parasitic on Australian fishes. X. Families Eudactylinidae and Pseudocycnidae. J. Natur. Hist. 4: 159–173.

1569. ZITKO, V. 1971. Determination of residual fuel oil contamination of aquatic animals. Bull. Environ. Contam. Toxicol. 5: 559–564.

1570. WILDISH, D. J., AND V. ZITKO. 1971. Uptake of polychlorinated biphenyls from sea water by *Gammarus oceanicus*. Mar. Biol. (Berlin) 9: 213–218.

1571. TSUYUKI, H., AND A. P. RONALD. 1971. Molecular basis for multiplicity of Pacific salmon hemoglobins: evidence for *in vivo* existence of molecular species with up to four different polypeptides. Comp. Biochem. Physiol. 39B: 503–522.

1572. ACKMAN, R. G., S. N. HOOPER, AND P. J. KE. 1971. The distribution of saturated and isoprenoid fatty acids in the lipids of three species of molluscs, *Littorina littorea*, *Crassostrea virginica* and *Venus mercenaria*. Comp. Biochem. Physiol. 39B: 579–587.

1573. BECK, B., T. G. SMITH, AND A. W. MANSFIELD. 1970. Occurrence of the harbour seal, *Phoca vitulina* Linnaeus, in the Thlewiaza River, N.W.T. Can. Field-Natur. 84: 297–300.

1574. QUAY, W. B., AND E. D. MITCHELL. 1971. Structure and sensory apparatus of oral remnants of the nasopalatine canals in the fin whale (*Balaenoptera physalus* L.). J. Morphol. 134: 271–279.

1575. SERGEANT, D. E. 1969. Feeding rates of Cetacea. Fiskeridir. Skr. Ser. Havunders. 15: 246–258.

1576. SANGALANG, G. B., M. WEISBART, AND D. R. IDLER. 1971. Steroids of a chondrostean: corticosteroids and testosterone in the plasma of the American Atlantic sturgeon, *Acipenser oxyrhynchus* Mitchill. J. Endocrinol. 50: 413–421.

1577. BURSA, A. S. 1970. *Dinamoebidium coloradense* spec. nov. and *Katodinium auratum* spec. nov. in Como Creek, Boulder County, Colorado. Arctic Alpine Res. 2: 145–151.

1578. BURSA, A. S. 1970. *Dinamoebidium hyperboreum* spec. nov. in coastal plankton of Ellesmere Island, N.W.T., Canada. Arctic Alpine Res. 2: 152–154.

1579. PLATT, T. 1971. The annual produciton by phytoplankton in St. Margaret's Bay, Nova Scotia. J. Cons. Int. Explor. Mer 33: 324–334.

1580. HUGHES, R. N., AND M. L. H. THOMAS. 1971. The classification and ordination of shallow-water benthic samples from Prince Edward Island, Canada. J. Exp. Mar. Biol. Ecol. 7: 1–39.

1581. SERGEANT, D. E. 1970. Migration and orientation in harp seals. Proc. Annu. Conf. Biol. Sonar Diving Mammals 7: 123–131.

1582. RICKER, W. E. 1970. A. N. Derzhavin's biostatistical method Ryb. Khoz. 46(10): 6–9, 46 (11): 5–7;

1971. Comparison of two reproduction curves. Ryb. Khoz. 47(3): 16–21, 47(4): 10–13. [In Russian]

1584. ZITKO, V., and S. N. TIBBO. 1971. Fish kill caused by an intermediate oil from coke ovens. Bull. Environ. Contam. Toxicol. 6: 24–25.

1585. STRASDINE, G. A. 1968. Amylopectin accumulation in *Clostridium botulinum* type E. Can. J. Microbiol. 14: 1059–1062.

1586. PLATT, T., AND R. J. CONOVER. 1971. Variability and its effect on the 24th chlorophyll budget of a small marine basin. Mar. Biol. 10: 52–65.

1587. LIPPS, J. H., J. W. VALENTINE, AND E. MITCHELL. 1968. Pleistocene paleoecology and biostratigraphy Santa Barbara Island, California. J. Paleontol. 42: 291–307.

1588. SAETHER, O. A. 1971. Nomenclature and phylogeny of the genus *Harnischia* (Diptera: Chironomidae). Can. Entomol. 103: 347–362.

1589. BURSA, A. S. 1971. Morphogenesis and taxonomy of fossil and contemporary Dinophyta secreting discoasters. Proc. Planktonic Conf. Roma 1970, 11: 129–143.

1590. BRETT, J. R. 1970. 3. Temperature. 3.3. Animals. 3.32. Fishes, p. 513–560. *In* O. Kinne [ed.] Marine ecology. Vol. 1. Environmental factors, Part. 1. Wiley-Interscience, London, New York, Sydney, and Toronto.

1591. ACKMAN, R. G. 1971. Pristane and other hydrocarbons in some freshwater and marine fish oils. Lipids 6: 520–522.

INTERPRETIVE ARTICLES OF THE FISHERIES RESEARCH BOARD OF CANADA

Abbreviation : A

58. FARLEY J., AND J. H. C. PIPPY. 1969. La démangeaison des nageurs. La Pêche au Canada Mai: 3–7.

109. THOMAS, M. L. H. 1969. L'herbicide 2,4-D. La zostère et sa répression. La Pêche au Canada Février: 3–7.

128. YATES, A. N. 1969. Les casiers à crevettes: objet d'expériences menées en C.-B. La Pêche au Canada Octobre: 3–8.

178. UTHE, J. F., F. A. J. ARMSTRONG, AND M. P. STAINTON. 1970. Rapid determination of residual levels of mercury in fish tissue and results of a check sample program. Rep. 5th Pesticide Residue Analysis Seminar, Vancouver, B.C., May. p. 156–164.

179. SANDEMAN, E. J. 1970. Comme un poisson dans l'eau. La Pêche au Canada Octobre: 9–11.

180. STEWART, J. E., AND H. RABIN. 1970. Gaffkemia, a bacterial disease of lobsters (genus *Homarus*), p. 431–439. *In* S. F. Snieszko [ed.] A symposium on diseases of fishes and shellfishes. American Fisheries Society, Washington, D.C., Spec. Publ. 5.

181. TEMPLEMAN, W. 1970. Reports on researches in the ICNAF area in 1969. Canadian research report, 1969. Subareas 1, 2 and 3. ICNAF Redbook 1970, Part II. p. 3–17.

182. SCOTT, J. S. 1970. Reports on researches in the ICNAF area in 1969. Canadian research report, 1969. Subareas 4 and 5. ICNAF Redbook 1970, Part II. p. 17–29.

183. PARSONS, T. R. 1970. Bases of resource management oceanography, p. 1–8. *In* Environmental management, a British Columbia priority. Primary Industries Programs, Center for Continuing Education, Univ. of British Columbia, Vancouver, B.C., Oct. 26–27, 1970.

184. MANSFIELD, A. W. 1970. Population dynamics and exploitation of some arctic seals. Antarctic Ecol. 1: 429–446.

185. WINTERS, G. H. 1967. The capelin, Newfoundland's latent resource. Nfld. J. Commer. 34(8): 7, 8, 46–47.

186. KABATA, Z. 1971. Review of "Infectious diseases of fishes and their control," edited by O. N. Bauer. J. Fish. Biol. 69: 2 p.

187. WALDICHUK, M. 1968. Sewage pollution in confined coastal waters. Pacific Search 68-16: 2 p.

188. LEBRASSEUR, R. J. 1968. Marine biology in Saanich Inlet. Pacific Search 68-21: 2 p.

189. RICKER, W. E. [ed.] 1968. Methods for assessment of fish production in fresh waters, p. 1–6, 255–269. IBP Handbook No. 3. Blackwell Scientific Publications, Oxford and Edinburgh.

190. LEAR, W. H. 1968. Greenland halibut. Nfld. J. Commer. 35(8): 21, 22, 38.

191. WELLS, R. 1968. Report on American plaice eggs and larvae. ICNAF Spec. Publ. 7(Pt. I): 181–182; (Pt. II): 266–278.

192. MAY, A. W. 1969. Marine fisheries for atlantic salmon. Arctic Circ. 19: 31–38.

193. WINTERS, G. H. 1969. Capelin (*Mallotus villosus*). Canadian fisheries, p. 94–101. *In* F. E. Firth [ed.] Encyclopedia of marine resources. Reinhold Publishing Corp., New York, N.Y.

194. FLEMING, A. M. 1969. Navigation. Newfoundland fisheries, p. 434–440. *In* F. E. Firth [ed.] Encyclopedia of marine resources. Reinhold Publishing Corp., New York, N.Y.

195. MAY, A. W. 1969. Labrador fisheries, p. 342–346. *In* F. E. Firth [ed.] Encyclopedia of marine resources. Reinhold Publishing Corp., New York, N.Y.

196. DICKIE, L. M. 1968. Review of "Fisheries biology: a study in population dynamics," by D. H. Cushing. Limnol. Oceanogr. 13: 729–730.

197. BEAMISH, F. W. H., AND L. M. DICKIE. 1967. Metabolism and biological production in fish, p. 215–242. *In* Biological basis of freshwater fish production. Blackwell Scientific Publications, Oxford and Edinburgh.

198. IDLER, D. R. 1970–71. Stable protein from the sea. Sci. Affairs 4: 85–87.

199. LORING, D. H. 1967. Resume of marine geological investigations carried out by the Atlantic Oceanographic Group in the Gulf of St. Lawrence, 1964–1966. Marit. Sediments 3(1): 24–26.

200. BLIGH, E. G. 1970. Mercury contamination in fish. Twentieth Annu. Inst. for Publ. Health Inspectors, Man. Dep. Health Social Develop., Oct. 19–23. 10 p.

201. BLIGH, E. G. 1971. Environmental factors affecting the utilization of Great Lakes fish as human food. Limnos 4: 10 p., 5 fig.

202. MAY, A. W. 1971. Salmon exploited at sea. The Mail-Star, February 19, p. 12–13.

203. TARR, H. L. A. 1970. Seafood — progress in sanitation and quality. E. L. Technical Symposium, Research and Development Department, Economics Laboratory, Inc., Mendota Heights, Minnesota, Sept. 16–17, 1970. 13 p.

204. FISHERIES RESEARCH BOARD OF CANADA. 1967. III. The research program. A. Progress in 1965 in Canadian research on problems raised by the protocol. INPFC Annu. Rep. 1965. p. 27–41.

205. MAY, A. W. 1971. Scientific problems relative to the West Greenland salmon fishery. Atlantic Salmon J. 1: 11–13.

206. HALLIDAY, R. G. 1970. 4T-V-W haddock: recruitment and stock abundance in 1970–71. ICNAF Redbook 1970 Part III. p. 84–95.

207. ILES, T. D., AND S. N. TIBBO. 1970. Recent events in Canadian Atlantic herring fisheries. ICNAF Redbook 1970 Part III. p. 134–147.

208. ILES, T. D. 1970. Vertebral numbers of the Bay of Fundy herring. ICNAF Redbook 1970 Part III. p. 148–151.

209. MACASKIE, I. B. 1971. A sea otter transplant to British Columbia. Fish. Can. 23(4): 3–9.

210. PARSONS, T. R. 1968. Review of "Marine chemistry. Vol. 1: Analytical methods," by D. F. Martin. Limnol. Oceanogr. 13: 726.

211. PARSONS, T. R., AND R. J. LEBRASSEUR. 1968. The availability of food to different trophic levels in the marine food chain, p. 325–343. *In* J. H. Steele [ed.] Marine food chains. Oliver and Boyd, Edinburgh.

212. BRETT, J. R. 1970. Fish — the energy cost of living, p. 37–82. *In* W. J. McNeil [ed.] Marine aquiculture. Oregon State University, Corvallis, Oreg.

213. WILDER, D. G. 1971. Artificial rearing of lobsters. Fish. Can. 23(3): 14, 15.
1970–71. L'élevage du homard ses perspectives. La Pêche au Canada Décembre–Janvier: 20, 21.

214. JANGAARD, P. M. 1969. Sex hormone research linked to development of fish farming. Fish. Can. 21(10): 9–11.

215. JANGAARD, P. M. 1967. Review of "Fishery by-products technology," by J. Brody. Trans. Amer. Fish. Soc. 96: 232–233.

216. VALLENTYNE, J. R. 1970. Phosphorus and the control of eutrophication. Can. Res. Develop. 3(3): 36–43, 49.

217. WATSON, J. 1969. Etude biologique du crabe des neiges *Chionoecetes opilio*. La Pêche au Canada Août: 13.

218. TARR, H. L. A. 1969. Fisheries research. Oceanol. Int. Yearbook 1969: 33–34.

219. HODDER, V. M. 1970. Recent events in the Canadian Atlantic herring fisheries (résumé). Proc. Can. Soc. Wildlife Fish. Biol. Atl. Chap. Annu. Meet. Nov. 4–6, 1970. p. 135–137.

220. JANGAARD, P. M. 1970. FRB scientists play important role in year-long research cruise. Fish. Can. 22(10): 16–18.

221. CHANDLER, R. A., AND J. C. MEDCOF. 1969. A catch 20 million years old. Fish. Can. 21(8): 15–16.

222. ANDERSON, J. M. 1971. Assessment of the effects of pollutants on physiology and behavior. Proc. Roy. Soc. London B 177: 307–320.

223. MANN, K. H., AND J. B. SPRAGUE. 1970. Combating pollution on the east coast of Canada. Mar. Pollut. Bull. 75–77.

224. LAWLER, G. H. Parasites of coregonid fishes, 279–309. *In* C. C. Lindsey and C. S. Woods [ed.] Biology of coregonid fishes. Univ. of Manitoba Press, Winnipeg, Man.

225. FISHERIES RESEARCH BOARD OF CANADA (Freshwater Institute, Winnipeg). 1971. FRB engineer invents portable fish plant for flying to remote locations. Can. Fisherman Ocean Sci. 57(1): 33.

226. DRUMMOND, G. I., AND M. YAMAMOTO. 1971. Nucleoside cyclic phosphate diesterases. *In* The enzymes. 3rd ed. Vol. 4. Chap. 16. p. 355–370.

227. DRUMMOND, G. I., AND M. YAMAMOTO. 1971 Nucleotide phosphomonoesterases. *In* The enzymes. 3rd ed. Vol. 4. Chap. 15. p. 337–354.

228. MANSFIELD, A. W. 1969. Review of "Jakob Danielsen — a Greenlandic painter," by Ph. Rosendahl. North March–April: 43.

229. SERGEANT, D. E. 1969. Review of "Age determination of mammals by layered structure in teeth and bones," by G. A. Klevezal' and S. E. Kleinenberg. (Transl. from Russian by Fish. Res. Bd. Can. Transl. Ser. No. 1024.) J. Mammal. 50: 163–164.

230. WEIR, J. R. 1971. Food from a northern environment. Can. Inst. Food Technol. J. 4(2): A24–A28.

231. HUNTER, J. G. 1971. Fisheries Research Board studies in Canada's Arctic. Can. Geograph. J. 82: 100–107.

232. WALDICHUK, M. 1971. Radioactivity in the marine environment. A summary. Nat. Acad. Sci. Nat. Res. Council, Washington, D.C. vi + 28 p.

233. JOHNSON, W. E., AND J. R. VALLENTYNE. 1970. Ecology and our pollution problems. Habitat 13(5&6): 4–9.

4082 6